ILLINOIS EDUCATION FOR TECHNOLOGY EMPLOYMENT PROJECT

FINAL REPORT
1984-85

Illinois
State Board of
Education

Adult,
Vocational and
Technical Education

Illinois Education
for Technology
Employment Project

Final Report
1984-85

Illinois
State Board of
Education

Walter W. Naumer, Jr.
Chairman

Ted Sanders
State Superintendent
of Education

Department of Adult,
Vocational and
Technical Education

Research and
Development Section

July 1985

Project Staff:

Administrative:

Richard W. Glogovsky
Project Director

Gregory A. Valentine
Project Coordinator

Mary E. Taylor
Project Secretary

Consultants:

Janet Robinson
Rose Meyer
William Kolton
Wilfred Pouler
Steven Gurevitz
Melvin Whitmer

Lake County Area Vocational Center
19525 West Washington Street
Grayslake IL 60030

Final Report Abstract Format

Official Project Title: EDUCATION FOR TECHNOLOGY EMPLOYMENT

Department of Adult, Vocational and Technical Education Funding Agreement Number: R-99-25-X-0000-499

Project Director: Richard W. Glogovsky

Funded Agency: Lake County Area Vocational Center

Location of Funded Agency: 19525 West Washington Street, Grayslake IL 60030

Time Period Covered: July 1, 1984 - June 30, 1985

Major Accomplishments of the Project:

See attached sheet

Potential Impact on Vocational Education:

The high tech program planning/development project has become a vehicle which can be used to help vocational centers and comprehensive high schools in program planning and staff development in preparing students for employment or advanced technology training at the community college level. The results of this project will be helpful to high schools, community colleges, and universities in developing sequential training paths for students. It will also assist teachers in preparing for the integration of math, science and high tech activities in their program areas. In addition to the Statement of Impact as outlined in the project proposal, it is anticipated that additional training sites (business and industry) will be identified and utilized by LCAVC staff in helping students gain additional high technology skills.

In conclusion, this project has served as a vehicle in bringing together high schools, area vocational centers and local community colleges as they plan together to best meet the education for employment needs for the area's youth and adults.

Products Delivered: (Indicate titles, types, quantity, recipients and date of delivery)

Ten copies of the final project report were delivered to the Illinois State Board of Education, Department of Adult, Vocational and Technical Education by July 31, 1985.

In addition, copies of sample student learning guides for the Secretarial Office Occupations, Machine Shop, Computer Assisted Drafting, Industrial Electrical Maintenance and Medical Assisting programs were also delivered to Springfield during FY85.

(Continuation of a. Final Report Abstract)

Major Accomplishments of the Project:

A. The Lake County Area High Tech Consortium membership has continued to provide input and recommendations concerning LCAVC involvement in the ETE project. Six meetings of this committee were held during the 1984-85 school year.

B. Project progress meetings were held with Project Coordinator Greg Valentine and Project Consultants Mel Whitmer and Will Pouler on an average of two times per week. Other meetings were held with LCAVC staff Jan Robinson, Rose Meyer, Bill Kolton, Ray Snider, Dawn Brumm, Joanne Fielding and Margaret Stanczak on an as-needed basis.

C. New technology CBVE curriculum developed in the areas of Machine Shop, Computer Assisted Drafting, Secretarial Office Occupations and Industrial Electrical Maintenance has been field tested during the school year.

D. Seven competency-based learning guides have been developed for the Industrial Electrical Maintenance program (tasks 210-216). A task list by occupational titles has also been developed for this program area. (These materials are included in Appendix I.)

E. Three competency-based learning guides have been developed for the Machine Shop (CNC) program (tasks 32-34), and have also been field tested during the school year. (These materials are included in Appendix II.)

F. Eight competency-based learning guides and a task list by occupational titles have been developed for the Medical Assisting program area (guides 002E, 003, 004, 100, 128, 530, 555 and 565). (These materials are included in Appendix III.)

G. Nine competency-based learning guides were developed and field tested for the Secretarial Office Occupations program area (tasks 170.B.5 - 170.B.14) (exc. 170.B.11). (These materials are included in Appendix IV.)

H. The following curriculum articulation meetings were held during the 1984-85 school year:

No. of Meetings	Program	Purpose	Educational Agencies
3	Computer Assisted Drafting	- Coordinate program content on a sequential basis, grades 12-14	LCAVC & CLC staff and administration
3	Health Occupations (Medical Assisting)	- Coordinate program content on a sequential basis, grades 9-14 - Develop a formal articulation agreement	Feeder district, LCAVC & CLC program staff and administration
4	Welding	- Coordinate program content on a sequential basis, grades 11-14 - Develop a formal articulation agreement	Feeder district, LCAVC & CLC staff and administration

(Continuation of a. Final Report Abstract)

No. of Meetings	Program	Purpose	Educational Agencies
4	Machine Shop	- Coordinate program content on a sequential basis, grades 11-14 - Develop a formal articulation agreement	Feeder district, LCAVC & CLC staff and administration
3	Electronics (Electronic Equipment Repair and Industrial Electrical Maintenance)	- Coordinate program content on a sequential basis, grades 11-14 - Develop a formal articulation agreement	Feeder district, LCAVC & CLC staff and administration
1	Food Service	- Joint utilization of LCAVC facility	LCAVC & CLC staff and administration
1	Business Data Processing	- Curriculum articulation and utilization of CLC facility for data processing	LCAVC & CLC staff and administration

I. At their April meeting, the Lake County Area Vocational Center Board of Control passed a "joint resolution" which identified the basis for enhancing program articulation and facility utilization between LCAVC and the College of Lake County. (See attached Joint Resolution - Appendix V)

J. As a result of those articulation meetings held with CLC and feeder district staff, a certificate of completion was developed for machine shop and welding programs. This certificate of completion was printed in bulk for each participating district offering a welding or machine shop program. Feeder district staff were directed to complete a certificate for each student and send a copy of the certificate to LCAVC for those students planning to enroll in LCAVC machine shop or welding programs. As a result, LCAVC staff would be able to better sequence learning activities and not duplicate those competencies presented in the feeder district programs. The same concept and procedure is being planned for implementation with the College of Lake County. (See attached Certificate of Completion - Appendix VI)

K. A final report including task list, competency-based curriculum, suggested equipment, labor market analysis and staff inservice training plan has been developed and is being submitted with the final report. This report deals with the subject of Information Processing.

L. The LCAVC Board of Control has given preliminary approval for offering a "Principles of Technology" program for 10th and 11th grade students at LCAVC.

M. LCAVC staff have been actively involved in a variety of staff development activities during the 1984-85 school year. (A summary of those activities is included in Appendix VII.)

N. Education/industry linkage has been initiated with Abbott Laboratories and Baxter Laboratories. One-week training slots with Abbott have been arranged for selected LCAVC and ETE staff during the summer of 1985. Additional LCAVC and feeder district staff will participate in this program during FY86.

b. Expenditure of Funds:

There were no major discrepancies between the Illinois State Board of Education/ Department of Adult, Vocational and Technical Education funding agreement amount and actual expenditures claimed for the project.

Salaries	$ 36,702.00
Materials and supplies	2,703.00
Transportation	3,250.00
Instructional equipment	19,911.20
Supportive services	12,900.00
Indirect costs	4,445.00
Total	$ 79,911.20

(See Appendix VIII for listing of equipment purchased)

c. Paid Participants in Activity:

Janet Robinson, Secretarial Office Occupations Instructor
Lake County Area Vocational Center
19525 West Washington Street
Grayslake IL 60030

Twelve years of experience as a vocational teacher and four years of experience in the secretarial work world.

William Kolton, Computer Assisted Drafting Instructor
Lake County Area Vocational Center
19525 West Washington Street
Grayslake IL 60030

Seven years of teaching experience, two years of work experience.

Wilfred Pouler, Retired Training Director, Outboard Marine Corp.
24101 - 119th Street
Trevor WI 53179

Thirty years of work experience, three years of teaching experience. Presently involved in authoring a text on CNC machinery.

Richard W. Glogovsky, Assistant Director
Lake County Area Vocational Center
19525 West Washington Street
Grayslake IL 60030

Twenty-five years of vocational education administrative and teaching experience. Eleven years of experience in curriculum development/research. Ten summers of work experience in the following: building trades, golf course maintenance, auto repair, welding, heavy equipment operation, proto-type machinist.

Rose Meyer, Medical Assisting Instructor
Lake County Area Vocational Center
19525 West Washington Street
Grayslake IL 60030

Seven years of teaching experience. Four years of work experience in the medical field.

Melvin Whitmer, Industrial Electrical Maintenance Instructor
Lake County Area Vocational Center
19525 West Washington Street
Grayslake IL 60030

Eight years of teaching experience in the electronics field. Fifteen years of work experience in electronic equipment repair.

Reme Tesch, Medical Laboratory Technology Instructor
College of Lake County
19351 West Washington Street
Grayslake IL 60030

Three years of medical lab teaching experience. Four years of work experience as a lab technician.

Virginia Murphy, Free-Lance Writer
Virginia Murphy & Associates
224 Burton Avenue
Waukegan IL 60085

Seven years of teaching experience (English). Five years of work experience as a free-lance writer and business development officer.

Mary Taylor, Administrative Secretary
Lake County Area Vocational Center
19525 West Washington Street
Grayslake IL 60030

Eleven years experience as administrative secretary (two years as project assistant). Two years experience as admissions officer at Northwestern University.

Leslie Taylor, Graphics Consultant
685 Garys Drive
Antioch IL 60002

B.S. degree in Industrial Technology, Major in Graphics, Illinois State University. Two years work experience in graphics field.

Steven Gurevitz, Machine Shop Instructor
Lake County Area Vocational Center
19525 West Washington Street
Grayslake IL 60030

Eleven years teaching experience in machine shop. Fifteen years work experience as a machinist.

d. Resource Listing:

(1) Material Resources:

(a) Occupational Outlook Handbook, Supt. of Documents, U. S. Government Printing Office, Washington DC 20402

(b) Fundamentals of Numerical Control, Delmar Publishing Co., 50 Wolf Rd., Albany NY

(c) American Machinist NC Machining Series (3 volumes), Beckwith Training Programs, Inc., 23500 Mercantile Rd., Cleveland OH 44122

(d) Independent Clinical Lab Facilities Listing, Illinois Department of Public Health, 2121 West Taylor, Chicago IL 60612

(e) Words That Sell, Caddylak Publishing, 201 Montrose Rd., Westbury NY 11590

(f) The Race We Dare Not Lose, American Association of School Administrators, Dept. 108, 1801 North Moore St., Arlington VA 22209

(g) Toward Individualized Learning, Addison-Wesley Distribution Center, Jacob Way, Reading MA 01867

(h) Standard Classification Manual, Supt. of Documents, U. S. Government Printing Office, Washington DC 20402

(i) You Can Give An Outstanding Speech or Presentation, Caddylak Publishing, 201 Montrose Rd., Westbury NY 11590

(j) Create Your Employee Handbook - Fast and Professionally, Caddylak Publishing, 201 Montrose Rd., Westbury NY 11590

(2) Human Resources:

A complete list of individuals who were not paid, but who contributed to the project are included as Appendix IX.

(a) LCAVC Board of Control

(b) Lake County ETE Consortium Members

(c) Advisory Committee Members from Computer Assisted Drafting, Electronic Equipment Repair, Health Care Assistant, Industrial Electrical Maintenance, Machine Shop, Medical Assisting, and Welding-Fabrication program areas

(d) Articulation Directory which includes feeder district, LCAVC and CLC vocational program instructors

e. Major Accomplishments and Significant Findings of the Project:

Objectives and Accomplishments:

1. By July 31, 1984, continue to utilize the High Tech Consortium (advisory committee) and seek input concerning suggestions for high tech programs and those necessary skills and knowledge required of students completing secondary and post-secondary vocational programs.

   Accomplishments: A High Tech Consortium composed of members from business, industry and education was formed and organized during the 1983-84 school year. This committee has continued to be utilized in

making suggestions in reference to new technology skills and knowledge required for employability. This committee also reviewed existing program curriculum and made suggestions foridentifying new subject content as well as equipment which should be integrated into the curriculum at LCAVC, its feeder districts and the College of Lake County.

2. By September 3, 1984, begin to field test newly developed curriculum materials and high technology equipment purchased for use in the Center's Secretarial Office Occupations Program (Word Processing) and Machine Shop Program (Computer Numeric Control).

   Accomplishments: Learning guides developed for the Wang information processing equipment were field tested in the Center's Secretarial Office Occupations program during the 1984-85 school year. Also, a series of learning guides related to Computer Numeric Control were developed and field tested with the Terco CNC mill and Emco CNC lathe.

3. From September 3, 1984, hold articulation meetings with feeder districts and community college on subjects related to math, science and those preliminary skills required of students entering into the Vocational Center and post-secondary high tech vocational programs.

   Accomplishments: Articulation meetings were held with a variety of program instructors and administrators from the feeder districts and the College of Lake County. As a result of those articulation meetings, a certificate of completion was developed for machine shop and welding programs. This certificate of completion was printed in bulk for each participating district offering a welding or machine shop program. Participating district staff were directed to complete a certificate for each student and send a copy of the certificate to LCAVC for those students planning to enroll in LCAVC machine shop or welding programs. As a result, LCAVC staff would be able to better sequence learning activities and not duplicate those competencies presented in the participating district programs. The same concept and procedure is being planned for implementation with the College of Lake County. (See Appendix VI - Certificate of Completion)

   Discussion of basic skills as they relate to science and math was included in the agendas of those meetings conducted during the year. It was decided that basic core skills (math and science) be integrated into existing vocational programs. The other option was to offer a specific course, i.e., Principles of Technology, to students interested in pursuing a career in technology.

4. By October 30, 1984, develop the necessary Action Plans which will give specific direction in which secondary vocational education programs can be designed to prepare students with high technology skills required for employment or entrance into post-secondary programs.

   Accomplishments: Action plans concerning the ETE projects were developed in part during the 1983-84 school year and updated to give specific direction in preparing students with high technology skills required for employment on entrance into post-secondary training programs.

Those specific action plans addressed the following issues:

a. Articulation with secondary and post-secondary schools, as well as public and private employment sector.

b. Surveying population characteristics, student interests and employment trends.

c. Identifying basic skills and methods for student acquisition of the same.

d. Identifying new programs and existing programs requiring updates to represent new technology.

e. Personnel training to train and update staff with new technology as it relates to their program area.

f. Plan and update facilities and equipment to meet the needs of individuals in presenting education for future employment

g. Providing support services to strengthen both program and employment placement for students, including an emphasis on individualized career planning for secondary and post-secondary students.

5. By January 18, 1985, participate as an informal test site in utilizing segments of the "Principles of Technology" curriculum developed by the Center for Occupational Research and Development (CORD).

   Accomplishments: Selected segments of "Force", "Work", and "Rate" taken from "Principles of Technology" CORD curriculum have been integrated into the Industrial Electrical Maintenance program. Three competency-based learning guides containing POT curriculum have been developed and field-tested in the Center's IEM curriculum during the 1984-85 school year. Copies of those learning guides have been included in the third quarterly report for FY85.

   A formal one-year POT program is planned to be offered to participating 10th and 11th grade students during the 1985-86 school year.

6. By June 30, 1985, update LCAVC and feeder district staff with new technology by utilizing staff development support available through the ETE project at Eastern Illinois University.

   Accomplishments: LCAVC staff have been actively involved in staff development activities during the 1984-85 school year. All $10,000 made available through Eastern Illinois University was utilized in updating LCAVC staff with new technology as it relates to their program areas. A complete list of participants and workshops attended are identified in Appendix VII.

f. Major Dissemination Activities:

1. Outcomes disseminated:

(a) High tech task lists, suggested high tech curriculum with supportive learning guides for the Secretarial Office Occupations Program (Information Processing), Machine Shop Program (Computer Numerical Control), Computer Assisted Drafting Program (CAD), Industrial Electrical Maintenance Program (Robotics), and Health Occupations Program (Medical Assisting) were disseminated during FY85.

(b) A comprehensive curriculum study on integrating information processing into a Secretarial Office Occupations program.

(c) An alternative type of staff inservice plan for staff interested in integrating new technology into their program areas (industrial visitations).

(d) Program curriculum articulation products developed jointly by LCAVC and feeder district staff. Generic task lists have been used and disseminated in order to eliminate duplication of information presented to feeder district students enrolling into LCAVC programs.

2. Target audiences:

(a) Feeder district high school vocational directors, counselors and faculty

(b) Area vocational center directors, counselors and faculty

(c) College of Lake County vocational-technical administrators, department and division chairs, and vocational, technical and occupational faculty

(d) University administrators, occupational department chairs and occupational training faculty

(e) State of Illinois ETE Directors

(f) DAVTE Research and Development Staff

g. Staff Development Activities:

Staff development activities were conducted on a continuous basis during the 1984-85 school year. Fourteen out of nineteen program staff members participated in workshops related to new technological changes in respect to their areas of concentration. A listing of those participants and the specific workshops attended is in Appendix VII.

h. Publicity:

A concentrated effort was made to publicize the Center's involvement in the ETE project and the products developed during the past two years. See Appendix X for ETE publicity developed during the 1984-85 school year.

i. Statement of Impact:

The new technology curriculum materials developed during the 1984-85 school year are very useful to vocational-technical teachers and administrators in updating their existing vocational programs. This material will help to make vocational programs more relevant with today's new technological manufacturing processes.

j. Conclusions and Recommendations:

Conclusions:

1. Project activities have helped vocational centers and feeder district high schools in program planning, staff development and equipment selection for the integration of new technology into their programs.

2. Project activities have improved communication and articulation between various feeder districts and promoted the regionalization concept of vocational education in Lake County.

Recommendations:

1. More effort will need to be placed in addressing the basic skill requirements of vocational students planning to enter into a specific technical career.

2. Administrative and staff cooperation between LCAVC, feeder districts and the College of Lake County will need to continue at a high level during the 1985-86 school year. Facilities, program offerings and equipment will need to be studied in detail and future program offerings will need to be identified based on quality, accessibility and cost.

3. Formal articulation agreements dealing with curriculum sequencing, facility usage and obtaining proficiency credit for knowledge acquired will need to be formalized with the appropriate institutions during the 1985-86 school year.

APPENDICES:

I. Industrial Electrical Maintenance Learning Guides and Task Listing by Occupational Titles

II. Machine Shop Learning Guides

III. Medical Assisting Learning Guides

IV. Secretarial Office Occupations Learning Guides

V. CLC/LCAVC Joint Resolution

VI. Certificate of Completion

VII. Staff Development Activities

VIII. Equipment Purchased

IX. Non-Paid Project Participants

X. Publicity

APPENDIX I

Industrial Electrical Maintenance Learning Guides

and

Task Listing by Occupational Titles

Illinois State Board of Education

Department of Adult, Vocational and Technical Education
Research and Development Section

Product Abstract

1. Title of material 7 Industrial Electrical Maintenance Learning Guides - titles listed on reverse side
2. Date material was completed FY85
3. Please check one: New material X Revised material ____ Field-tested material ____
4. Originating agency Lake County Area Vocational Center

   Address 19525 West Washington Street, Grayslake IL Zip Code 60030
5. Name(s) of developer(s) Melvin Whitmer

   Address Lake County Area Vocational Center Zip Code ____
6. Developed pursuant to Contract Number R=99-25-X-0000-499

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7. Subject Matter (Check only one according to Department of Education Code):

   Code

   ____ 01 Agricultural Education
   ____ 03 Business and Office Education
   ____ 04 Distributive Education
   ____ 07 Health Occupations Education
   ____ 09 Home Economics Education
   ____ 10 Industrial Arts Education
   ____ 16 Technical Education
   X 17 Trade and Industrial Education
   ____ 22 Cooperative Education
   ____ Career Education
   ____ Other (Specify) ____

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8. Education Level:

   ____ Pre-K Thru 6
   ____ 7-8
   ____ 9-10
   X 11-12
   X Post-Secondary
   X Adult
   ____ Teacher (Pre-service)
   ____ Administrator (Pre-Service)
   ____ Other (Specify) ____

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9. Intended for Use By:

   X Student
   X Classroom Teacher
   X Local Administrator
   ____ Teacher Educator
   ____ Guidance Staff
   ____ State Personnel
   ____ Other (Specify) ____

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10. Student Type:

    X Regular
    ____ Disadvantaged
    ____ Handicapped
    ____ Limited-English Proficiency
    ____ Other (Specify) ____

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11. Medium and Format of Materials:

    X HARDCOPY
    ____ VIDEOTAPE
    ____ FILM
    ____ MICROFICHE

    No. of pages various
    ____ Paper bound
    ____ Hard bound
    X Loose-leaf
    Photos: Yes ____ No ____
    Diagrams: Yes ____ No ____

    ____ Minutes
    ____ B & W
    ____ Color
    ____ inches

    ____ Minutes
    ____ B & W
    ____ Color
    ____ mm

    ____ B & W
    ____ Color

___ SLIDES ___ FILM STRIPS ___ AUDIO ___ OTHER

No of frames ____
___ B & W
___ Color
___ Audio
___ Carousel provided
___ Other packaging used
(Specify) _____

No of frames ____
___ B & W
___ Color
___ Audio

___ Automatic synch
___ ____ Hz
___ Manual cue
___ Reel
___ Cassette
___ Cartridge

Specify:
_____
_____
_____

12. Availability:

____ One copy free
X In ERIC system (No. _____)
For sale @ $ ____ per copy
____ Not available
____ Loan copy available

Contact: Name East Central Network for Curriculum Coord. Phone (217) 786-6375
Illinois Vocational Curriculum Center
Address Sangamon State University, Building F Zip Code 62708
Springfield IL

13. Copyright Restrictions:

Contact: Name NONE Phone ( )
Address Zip Code

14 What level(s) of assistance is required to provide implementation of this outcome?

____ awareness X understanding
____ deciding X implementing

15. Are Consultive/Inservice (or staff development) available? Yes____ No____

Contact: Illinois State Board of Education
Department of Adult, Vocational and Technical Education
Research and Development Section, E-426
100 North First Street
Springfield, IL 62777
(217) 782-4620

16 General Description (State the general objective and suggested method of use. Summarize the content and tell how it is organized. Write the description so that it can be used to promote the material. Continue on back of this sheet or on another sheet, if necessary.)
Competency-based learning guides for learning basic skills/knowledge

17 Person Completing this Abstract. Richard W. Glogovsky
Lake County Area Vocational Center
Full Address 19525 West Washington Street
Grayslake IL 60030

LEARNING GUIDE TITLES:
1. Identify fluid system schematic symbols
2. Describe unified technology concepts
3. Identify fluid system components
4. Connect fluid system valves
5. Connect fluid system actuators
6. Connect venturi vacuum generator
7. Describe pressure and force in a fluid system

LAKE COUNTY AREA VOCATIONAL CENTER

COMPETENCY-BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

STUDENT LEARNING GUIDE

Produced By M.H. WHITMER Date 1/85

TASK: IDENTIFY FLUID SYSTEM SCHEMATIC SYMBOLS

PURPOSE: You must understand the principles of fluid systems as they apply to robotics and automated manufacturing. The intermediate objectives under this task presents the schematic symbols and interconnections to help you achieve the needed understanding. The modern electrical maintenance person knows how fluid systems work so that troubles can be identified and repairs effected rapidly.

INDUSTRIAL ELECTRICAL MAINTENANCE

Program	Task	Est.Time	Prereq.
17.1002	210	2 hrs	NONE

edk

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME _____ SOCIAL SECURITY NUMBER _____

LENGTH OF CONTRACT (NORMAL TIME IN HOURS) _____

2. TERMINAL PERFORMANCE OBJECTIVE

Given a written evaluation, you will identify fluid system symbols. You must score 100% on the written test for this objective.

2a. INTERMEDIATE OBJECTIVE(s)

1. Identify the physical parts location on the pneumatics trainer.
2. Identify the graphic symbols for the components used fluid systems.

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____. I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

Student's Signature _____

Instructor's Signature (verifies competency) _____

INTERMEDIATE OBJECTIVE

Identify the physical parts location on the pneumatics trainer.

LEARNING STEPS (Activities)	RESOURCES
1. Read the information sheet cited in resource #1 to learn the function of the trainer.	1. Information sheet #1, page 4, is entitled "Brat 500"
2. Perform the action called for on the procedure sheet cited in resource #2	2. Procedure sheet #1, pages 6 and 7 are entitled "Trainer Familarization"
3. Complete the self-help performance checklist cited in resource #3 to assure mastery of the objective.	3. Self-help performance checklist #1, page 8 is entitled "Parts Location"
4. Proceed to the next objective	4. The next objective starts on page 10.

INFORMATION SHEET #1

BRAT 500
CONNECTING COMPONENTS AND BUILDING CIRCUITS

Pneumatic connections between components are made with 1/16" pneumatic tubing and barb fittings. (See the barb fitting in illustration #1). To make connections, slide the tubing over the barb fittings and apply pressure so that the tubing covers the entire barb. You may choose to keep the tubing connected to the output quick disconnects to save class room time.

To remove tubing from components, grasp tubing just above the barb fitting and pull off fitting.

ILLUSTRATION #1

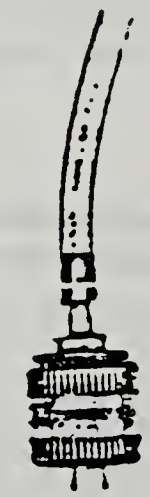
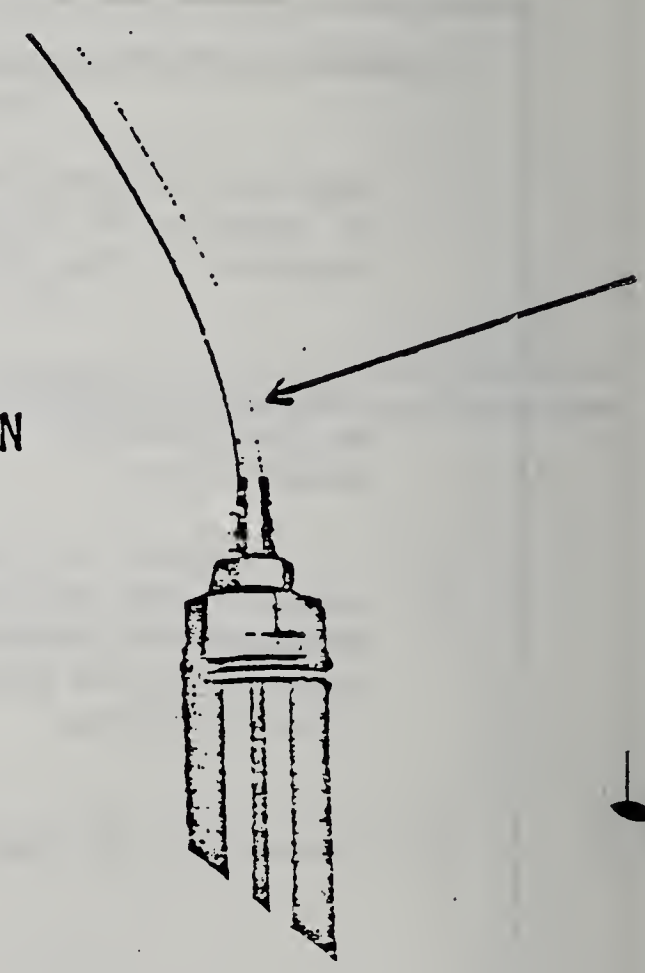


ILLUSTRATION #2



AIR LEAKS

Many experiments will not reflect true component action if any sizeable leaks take place. After a period of tine and continuous use of component circuit acitivities; you may develop a slight air leak at the barb fitting and tubing connection. (See illustration #2). This may occur if the tubing gets stretched out of shape. If this happens, simply cut off the end of the tubing and reconnect.

SYMBOLS

All symbols used on the activities are considered standard by all industrial requirements and are the U.S.A. STANDARD GRAPHIC SUMBOLS, however, when you enter field work you will see some minor variances from schematic to schematic.

CAUTION: AVOID CLEANING TUBING WITH ANY CHEMICAL CLEANING FLUIDS.

SAFETY

Always use care when releasing compressed air near nose, ears, or throat. Serious injury or death have been caused by thoughtless use of compressed air. Recommended operating air pressure of the BRAT 500 should not exceed 60 psi.

PROCEDURE SHEET #1

TRAINER FAMILIARIZATION

OBJECTIVE: To identify each operational portion of the BRAT 500 and how to apply them to the following activities.

MATERIALS NEEDED:
1 - BRAT 500
1 - 60 PSI AIR SUPPLY
1 - 115 VAC GROUNDED POWER SOURCE
1 - STUDENT LEARNING GUIDE 210
1 - PENCIL

PROCEDURE USING THE ILLUSTRATIONS ON THE FOLLOWING PAGES, AND FOLLOWING EACH TESTING PROCEDURE YOU WILL HAVE YOUR FIRST OPPORTUNITY TO DEMONSTRATE EACH PORTION OF THE BRAT 500 TRAINER.

NOTE: CHECK OFF EACH STEP THAT YOU MASTER SO THAT YOU WILL RECORD YOUR PROGRESS.

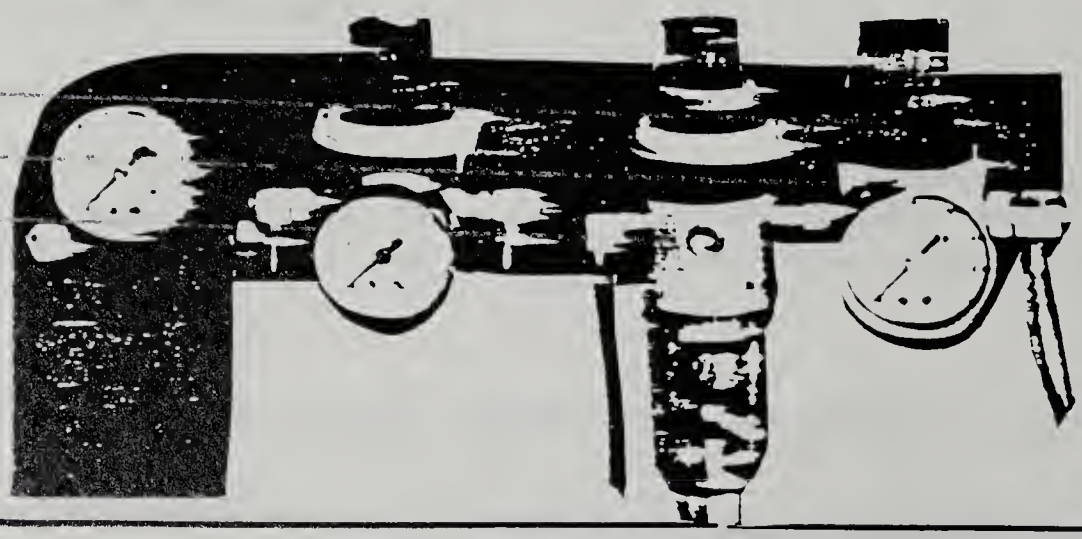
_____ STEP #1 - Connect your laboratory air supply to the air inlet connector provided on the BRAT 500 (See Illustration #3).

_____ STEP #2 - Connect the three prong grounded line cord on the BRAT 500 to the 115 VAC outlet.

_____ STEP #3 - Using the illustration below, locate the instrument and test station panel and observe the following components; TEST GAUGE: used to test and record pressure within a circuit. REGULATED PRESSURE STATIONS: Used to isolate a desired pressure within a circuit. FILTER AND REGULATOR: Used to regulate and filter the incoming air supply to the trainer.

_____ STEP #4 - Locate the component storage board, the storage board houses the various components used on the proceeding activities. After each experiment, replace all components to this area to avoid misplacing any components.

_____ STEP #5 - Locate the Valve and Manifold Assembly. The valve pack supplied has seven manifolds with two air piloted valves, two electric piloted valves, two manual piloted valves and one blank manifold for expansion or addition of advanced pneumatic kits. All valves are removable and interchangeable with all manifolds.



Step #6

The 12 volt output jacks are located directly below the valve assembly and is used to power the electric piloted single and double solenoid valves. Each output jack is powered by the 12 volt input switches and all operate independent of each other.

Step #7

The Power On/OFF switch supplies the power source for the 12 volt outputs and must be activated to use the electric piloted valves.

Step #8

Locate the Pneumatic Input switches. The input switches activate the corresponding pneumatic output ports when the fast connectors supplied are screwed completely down. The input switches are not used for activating the manual piloted valves, or the electric piloted valves.

Step #9

The work surface is used to assemble circuits using the components supplied.

Step #10

Note that each pneumatic input and output is shown on the illustration with an "a" or "b" assigned. This denotes the A and B ports on the manifolds and will be referred to in various activities. Further explanation of these ports will be discussed in later activities.

Step #11

Adjust the Filter Regulator to read 40 PSI on the gauge.

Step #12

Activate PNEUMATIC INPUT swtich 1A, place a fast cibbect barb on PNEUMATIC OUTPUT PORT 1A and slowly screw it on. What did you observe?

_____

_____

_____

NOTE: ALL FAST CONNECTORS REACT THE SAME.

Step #13

Turn the POWER switch to the ON position, take the leads from the single solenoid electric valve and plug into the 12 volt output jack numbered 1. Place a fast connector on output 3A and activate the 12 volt input switch #1. What did you observe? _____

_____

_____

Step #14

REVIEW EACH OF THE STEPS YOU HAVE JUST COMPLETED AND ASSURE YOURSELF THAT YOU HAVE MASTERED THE CORRECT LOCATION OF EACH PART

PERFORMANCE/PRODUCT CHECKLIST

Program: INDUSTRIAL ELECTRIC MAINTENANCE

Task No:

Identify the physical parts location on the pneumatic trainer.

Student's Name: _____ Date Of Attempt: _____

Evaluator's Name: _____ Evaluation Site: _____

Performance Attempt: 1 2 3 4

Terminal Performance Objective:

Given a written evaluation, you will identify fluid system symbols. You must score 100% on the written test for this objective.

Directions To The Student:

Before attempting this task for mastery, carefully review this checklist. You will be evaluated on the basis of this checklist. When you feel you are ready for evaluation, contact your instructor. You must complete your performance within 30 minutes and must score at least 10 out of 10 points or 100 % for mastery. Critical items are marked with an asterisk (*). These items must be satisfactorily completed.

Directions To The Evaluator:

The student will contact you when ready for the evaluation. The student must complete the performance within 30 minutes and must score 10 out of 10 points or 100 % and all items marked with an asterisk (*) must be satisfactorily completed.

CRITICAL ITEMS	ITLMS TO BE OBSERVED OR CHECKED	RATING	
		YES	NO
	Parts location		
	Lever valve		
	Solenoid valve		
	Air piloted valve		
	Test Gauge		
	Output Ports		
	Input indicators		
	Power Indicator		
	Pneumatic inputs		
	Pressure regulator		
	12 volt jacks		
	TOTAL POINTS EARNED =		

POINTS NEEDED FOR MASTERY = 10
TOTAL POINTS POSSIBLE = 10

INTERMEDIATE OBJECTIVE

Identify the graphic symbols for the components used in fluid systems.

LEARNING STEPS (Activities)	RESOURCES
1. Read the information sheet cited in Resource #1 to learn about the symbols used in fluid systems.	1. Information Sheet #2 page 11-12 entitled "Graphic Symbols".
2. Follow the steps given in Procedure Sheet cited in Resource #2 to relate symbol and physical appearance.	2. Procedure Sheet #2, page 13 to 14 is entitled "Table of Symbols."
3. Complete the self - help evaluation cited in Resource #3 to assure mastery of the objective.	3. Self-help evaluation #2, page 16 entitled "Symbol Identification".
4. Complete the evaluation instrument for this terminal performance objective.	4. See your instructor for the evaluation instrument.
5. Proceed to the student learning guide.	5. See your instructor.

INFORMATION SHEET #2

GRAPHIC SYMBOLS

Graphic symbols for fluid power diagrams have been developed by the American National Standards Institute (ANSI) to provide a means of communication standards that serve industry and education. The standards serve to simplify design, fabrication, analysis and servicing of fluid power systems; they have no language barriers.

The ANSI Graphic System utilizes elementary geometrical forms to depict components and circuits. These forms include: circles, squares, rectangles, triangles, arcs, arrows, lines, dots and crosses.

The symbols attempt to describe component function rather than construction. In addition, they provide a means of showing how many of the fluid power components operate hydraulically, electrically, manually, etc. The standards include basic symbols which differentiate between hydraulic and pneumatic fluid components and circuits.

In addition to graphic symbols, fluid power systems and components can be illustrated with pictorial and cutaway symbols. Pictorial symbols are useful for showing the interconnections of components, but are difficult to standardize from a functional basis. Cutaway symbols are used to emphasize construction, but are complex to draw and they do not readily indicate functions.

In order to use the system to its maximum potential, the following general rules must be understood and followed:

*Symbols show connection, flow paths and function of components represented. They do not indicate condition occuring during transition form one flow path arrangement to another. Further, they do not indicate construction or values such as pressure flow rate, and other component settings.

*Symbols do not indicate location of ports, direction of shifting of spools or position of control elements on an actual component.

* The position of size of a symbol can be altered, for component emphasis in an circuit, without changing its meaning.

*Each symbol is drawn to show normal or neutral condition of component unless multiple circuit diagrams are furnished showing various phases of circuit operation.

*Arrows used within symbol envelops show direction of fluid flow in a component as used on the application represented, Double-end arrows indicate reverse flow.

INFORMATION SHEET #2

SYMBOLS

All symbols used in the activities are considered standard by all industrial requirements and are the U.S.A. standard graphic symbols. However, when you enter field work you will see some minor variances from schematic to schematic.

CAUTION

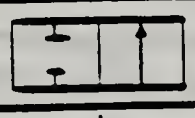
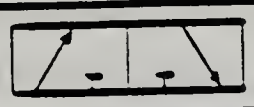
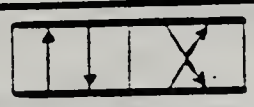
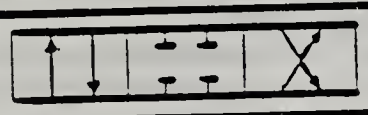
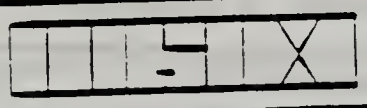
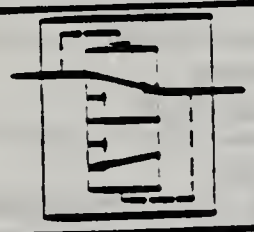
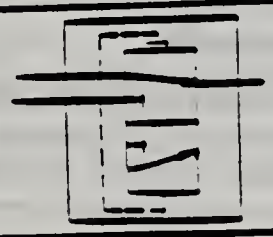
Avoid cleaning tubing with any chemical cleaning fluids.

SAFETY

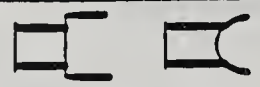
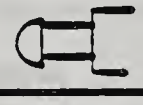
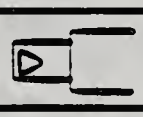
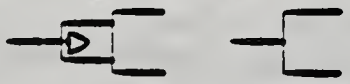
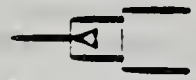
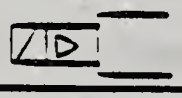
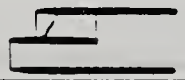
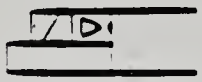
Always use care when releasing compressed air near eyes, nose, ears, or throat. Serious injury or death have been caused by thoughtless use of compressed air. Recommened operating air pressure of the BRAT 500 should not exceed 60 PSI.

The BRAT 500 requires a 115VAC power source input. The BRAT 500 is grounded and fused and has a 12-16 volt output for safety. If you have any questions about safety procedures, advise your instructor.

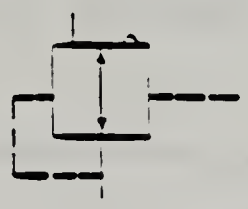
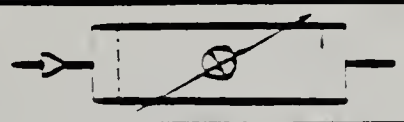
PNEUMATIC VALVES

SYMBOL	DESCRIPTION
	CHECK
	CHECK PILOT OPERATED TO OPEN
	CHECK PILOT OPERATED TO CLOSE
	2 POSITION 2 WAY
	ON - OFF SIMPLIFIED
	2 POSITION 3 WAY
	2 POSITION 4 WAY
	2 POSITION, 4 WAY 5 PORTED
	3 POSITION, 4 WAY PORTS CLOSED, CENTER POSITION
	3 POSITION, 4 WAY, 5 PORTED (Cylinder ports open to pressure in center pos.)
	3 POSITION, 4 WAY, INFINITE POSITIONING (Cylinder ports open to exhaust in center pos.)
	QUICK EXHAUST
	SHUTTLE

VALVE ACTUATORS

SYMBOL	DESCRIPTION
	MANUAL GENERAL SYMBOL
	PUSH BUTTON
	LEVER
	PEDAL OR TREADLE
	MECHANICAL CAM- TOGGLE ETC.
	SPRING
	DETENT LINE INDICATES WHICH DETENT IS IN USE
	SOLENOID
	INTERNAL PILOT SUPPLY
	REMOTE PILOT SUPPLY COMPLETE SIMPLIFIED
	INTERNAL PILOT EXHAUST
	PILOT EXHAUST TO ATMOSPHERE
	PILOT DIFFERENTIAL COMPLETE SIMPLIFIED
	AND COMPOSITE SOLENOID AND PILOT
	OR COMPOSITE SOLENOID OR MANUAL OVERRIDE
	AND/OR COMPOSITE Solenoid and pilot or manual override
	AND/OR COMPOSITE. Solenoid and pilot or MANUAL override and pilot

AIR PREPARATION UNITS

SYMBOL	DESCRIPTION
	FILTER SEPARATOR WITH MANUAL DRAIN
	FILTER SEPARATOR WITH AUTOMATIC DRAIN
	AUTOMATIC DRAIN
	LUBRICATOR LESS DRAIN
	LUBRICATOR WITH MANUAL DRAIN
	LUBRICATOR WITH AUTOMATIC FILLING
	AIR-LINE PRESSURE REGULATOR ADJUSTABLE RELIEVING
	AIR-LINE PRESSURE REGULATOR PILOT - CONTROLLED RELIEVING
	AIR-LINE COMBO F R L SIMPLIFIED

EVALUATION SHEET
SELF-HELP EVALUATION # 3

1. Describe and list four application of pneumatics:

_____

_____

_____

2. Name the three methods of transmitting power:

_____

_____

_____

3. List four advantages and two disadvantages of pneumatic power:

_____ _____

_____ _____

_____

_____

_____

4. What technologies are considered FLUID POWER:

_____

_____

5. What GAS LAWstates, Pressure in liquid or gas in a confined body acts equally in all directions, and always at right angles to the containing surfaces:

_____

6. What is the formula for BOYLE'S LAW:

7. TRUE or FALSE, Pneumatic power is fast to repond to stopping and starting.

_____

PROGRAM INDUSTRIAL ELECTRICAL MAINTENANCE

CRITERION EXAM

TASK = 210 IDENTIFY FLUID SYMBOLS

DIRECTIONS:

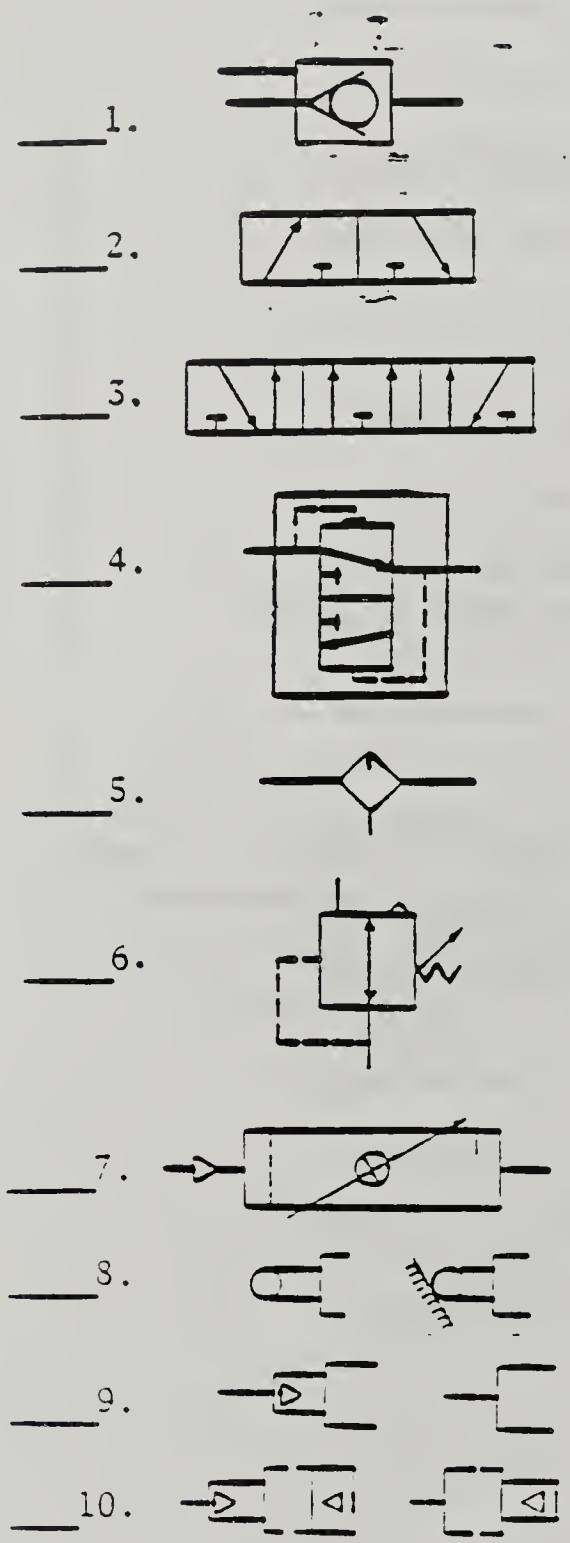
THE PURPOSE OF THIS EXAM IS TO DETERMINE WHETHER OR NOT YOU HAVE UNDERSTOOD THE INFORMATION ON FLUID SYMBOLS AND THEIR RELATED PHYSICAL COMPONENTS.

Each of the questions or incomplete statements below is followed by several words, phrases, or a series of numbers. Choose the one which best answers the question or completes the statement correctly. Place the letter associated with that choice (A,B,C or D) in the numbered blank space on your ANSWER SHEET. DO NOT WRITE ON THIS TEST!!! To master this exam you must answer 10 out of 10 items correctly, 100 %.

EVALUATION SHEET

CRITERIA EXAM FOR 210

Match symbol with description. Place letter before number.



A. LUBRICATOR WITH MANUAL DRAIN

B. QUICK EXHAUST

C. MECHANICAL CAM TOGGLE ETC.

D. CHECK PILOT OPERATED TO OPEN

E. PILOT DIFFERENTIAL
COMPLETE SIMPLIFIED

F. 3 POSITION, 4 WAY, 5 PORTED
(CYLINDER PORTS OPEN TO PRESSURE IN CENTER POS.)

G. AIR-LINE PRESSURE REGULATOR
ADJUSTABLE RELIEVING

H. REMOTE PILOT SUPPLY
COMPLETE SIMPLIFIED

I. 2 POSITION
3 WAY

J. AIR-LINE COMBO F R L
SIMPLIFIED

LAKE
COUNTY
AREA
VOCATIONAL
CENTER

COMPETENCY-BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

STUDENT LEARNING GUIDE

Produced By M.H. WHITMER Date 1/85

TASK: DESCRIBE UNIFIED TECHNOLOGY CONCEPTS

PURPOSE: You must understand the principles of unified technology concepts as they apply to robotics and automated manufacturing. The intermediate objectives under this task present the unified concepts to help you achieve the needed understanding. The modern electrical miantenance person knows the unified technology concepts so that troubles can be identified in the correct system and repairs effected rapidly.

INDUSTRIAL ELECTRICAL MAINTENANCE

Program	Task	Est.Time	Prereq.
17.1002	211	2 hrs	210

edk

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME _____ SOCIAL SECURITY NUMBER _____

LENGTH OF CONTRACT (NORMAL TIME IN HOURS) _____

2. TERMINAL PERFORMANCE OBJECTIVE

Given a written evaluation, you will describe the unified technology concepts as they apply to fluid systems. You must score 100% on the written test for this objective.

2a. INTERMEDIATE OBJECTIVE(s)

1. Identify the fundamental principles of fluid systems.
2. Describe the methods of doing work in the fluid system.
3. Describe the rate of fluid flow in the fluid system.
4. Describe the similarities of related technology circuits and components.

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____. I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

Student's Signature _____

Instructor's Signature (verifies competency) _____

INTERMEDIATE OBJECTIVE #1

IDENTIFY THE FUNDAMENTAL PRINCIPLES OF FLUID SYSTEMS.

LEARNING STEPS (Activities)

1. Read the information sheet cited in Resource #1 to learn about fluids.
2. Identify the fluid laws cited in Resource #2 to learn about the gas laws.
3. Complete the self-help evaluation cited in Resource #3 to determine your level of understanding.
4. Proceed to the next Intermediate Objective to continue your progress.

RESOURCES

1. Information Sheet #1, pages 4 and 5 are entitled "Fundamentals of Pneumatics."
2. Information Sheet #2 pages 6 and 7 are entitled "Basic Gas Laws."
3. Self-help evaluation #1 page 8 is entitled "Principles of Fluid Systems."
4. Intermediate Objective #2 begins on page 9.

INFORMATION SHEET #1

FUNDAMENTALS OF PNEUMATICS

Man has always searched for new ways to extend his physical capabilities by harnessing and using energy produced by nature. The study of power technology concerns energy sources, the conversion of those sources, and the method of transmitting power for many industrial and technical applications. There are three methods of transmitting power: (1.) electrical, (2.) mechanical and (3.) fluid power which includes pneumatics and hydraulics. In this student guide, you will study the control and transmission of power through pneumatics.

Over the past two decades fluid power has had a great impact and influence on American industry. Over 85% of all automated systems depend upon pneumatics and hydraulics for muscle power.

Fluid power is the main source for many applications such as robotics, feeding systems, air cooling and heating, parts positioning and lifting heavy payloads. Many industries such as agriculture, chemical process, construction, materials handling, steel production, transportation and robotics depend upon the use of fluid power.

Some of the advantages and disadvantages of fluid systems are:

ADVANTAGES

1. Clean and safe from fire.
2. Easy to store.
3. Speed, fast response to starting and stopping.
4. Quiet operation if properly muffled.
5. No return line needed.
6. Readily available.
7. Efficient method of multiplying force.

DISADVANTAGES

1. Expensive
2. Has pressure limits.
3. Possible leakage.
4. Compressibility is a safety hazzard.

On the following page, you will see several pictures representing the multitude of applications for pneumatic control and actuation.

INFORMATION SHEET (Cont.)

FLUID POWER APPLICATIONS WORLDWIDE

aviation

agriculture

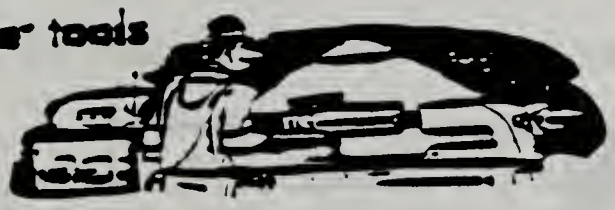
chemicals

petroleum

food processing

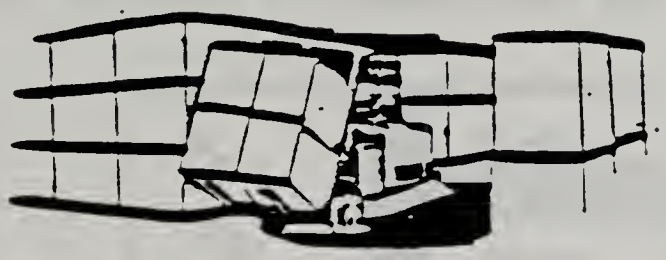
marine

metalworking and machine tools



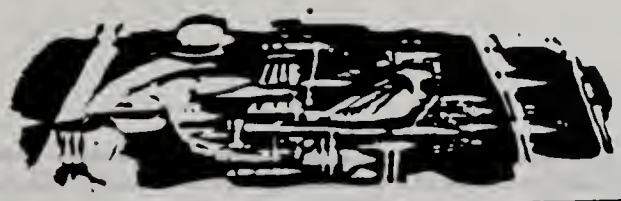
lumber

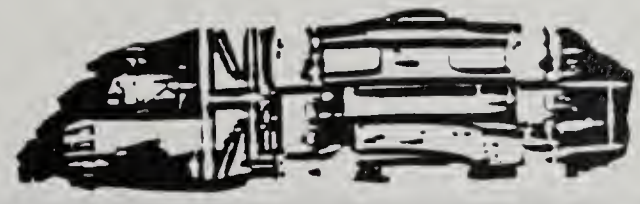
material handling



construction

mining





steel

Program	Task	Page
17.1002	211	5

INFORMATION SHEET #2

BASIC GAS LAWS

PASCAL'S LAW:

Pressure in liquid or gas in a confined body acts equally in all directions, and always at right angles to the containing surfaces, because air and hydraulic fluids act according to Pascal's Law that force and motion can be transmitted through them. Fluid or air will take the shape of its container.

CHARLES' LAW:

A gas reacts to a change in temperature much the same way as to changes in pressure. If the temperature increases, the pressure increases on the same ratio providing the volume stays the same. The principle of a gas's reaction to changes in temperature is called CHARLES' LAW.

BERNOULLI'S LAW:

The higher the speed of a flowing gas, the lower the pressure. If the speed decreases, the pressure increases and equally as the speed increases, the pressure decreases.

BOYLE'S LAW:

When the temperature stays the same, the volume of a given mass of gas varies inversely as its absolute pressure.

This means when we compress a gas, we push the molecules closer together. Then compressing a gas to half its original volume doubles the density of the molecules. It also doubles the rate that the molecules strike into the walls of the container, which doubles the gas pressure against the container walls. When a given mass of gas expands to twice its original volume, the molecules are farther apart and the number of times that the molecules stike the container wall is cut in half. This relationship is shown in the diagram below.

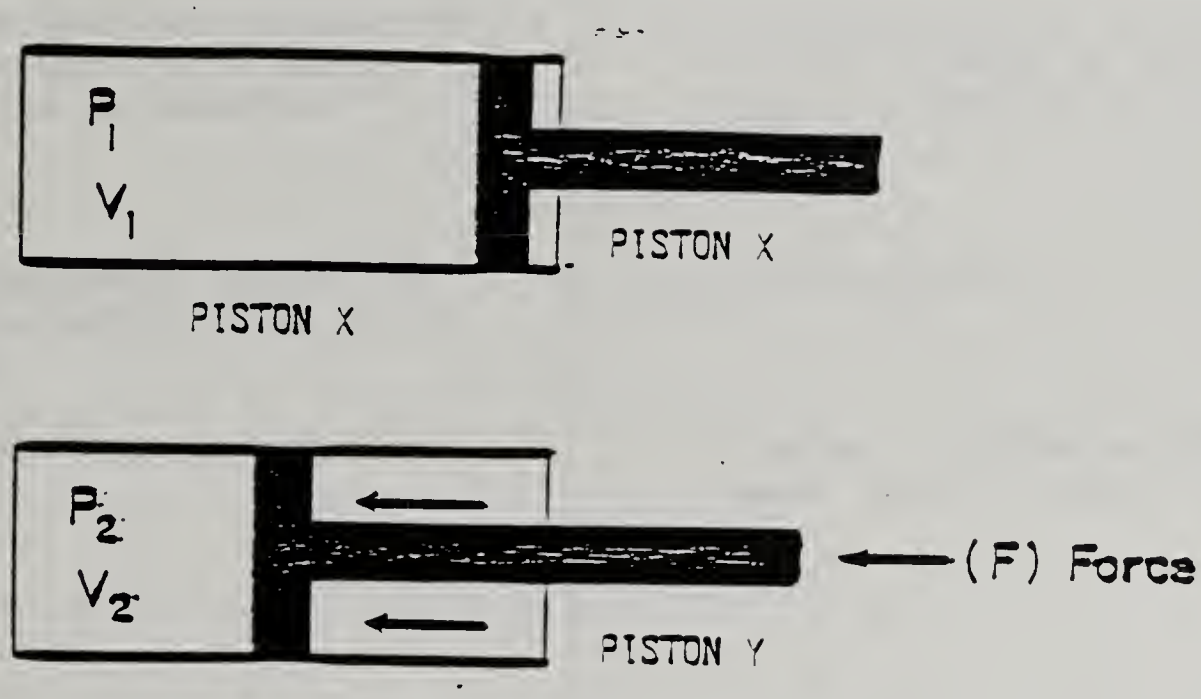
This relationship is a simple but very important formula which is used in analyzing pneumatic systems.

$$P1\ V1 = P2\ V2 \text{ or } P2 = \frac{P1\ V1}{V2}$$

P1 is the initial pressure os psia
P2 is the final pressure in psia
V1 is the initial volume in cubic inches or cubic feet
V2 is the final volume in cubic inches or cubic feet

Starting with cylinder x having a volume V1 and a gas pressure of P1. When we place a force on the piston Y, the volume is decreased and the pressure os increased.

EXAMPLE: V2 is 1/2 V1, then ZP2 will be 2 times P1.



SELF-HELP EVALUATION #1

PRINCIPLES OF FLUID SYSTEMS

ANSWER THE FOLLOWING.....READ CAREFULLY.

1. FLUID SYSTEMS INCLUDE _____ AND _____ SYSTEMS.

2. Pneumatics advantages: (Select one that is inappropriate).

3. Gas pressure is _____ on all surfaces of a container.

4. A temperature rise causes gases to _____.

5. A gas pressure decrease causes a temperature _____.

6. Charles Law states:

7. Bernoulli's Law states:

8. Boyle's Law states:

INTERMEDIATE OBJECTIVE #2

Describe the methods of doing work in a fluid system.

LEARNING STEPS (Activities)	RESOURCES
1. Read the information sheet cited in Resource #1 to discover work in fluid systems.	1. Information Sheet #3 pages 10 - 25 are entitled. "Work in fluid systems."
2. Complete the self-help evaluation cited in Resource #2 to determine your level of understanding.	2. Self-help evaluation #2, page 26 entitled "Work".
3. Perform the activities cited in Resource #3 to develop math skills.	3. Activity Sheet #1 page 28 to 38, entitled, "Work math skills."
4. Read information sheet cited in Resource #4 to discover the work done by a piston.	4. Information Sheet #4 pages 41 - 43 are entitled "Work done by a piston".
5. Complete the self-help evaluation cited in Resource #5 to assure mastery of the intermediate objective.	5. Self-help evaluation #3 is entitled, "Work in Fluid Systems", page 44.
6. Have your instructor review the self-help evaluation cited in Resource #5.	6. See instructor.
7. Proceed to the next Intermediate Objective.	7. The next Intermediate Objective guide starts on page 45.

A TECHNICIAN TALKS ABOUT WORK

"I'm a technician in an automobile assembly plant. My job description includes being responsible for maintaining the plant's manufacturing equipment. Our plant recently has been rebuilt to use automated equipment for production work. This means that computer-controlled, mechanical conveyor systems take parts from one work station to another. Computers also control our machining equipment. Robots are used to fit parts together, weld auto bodies and spray-paint finishes. Heat lamps or ovens are used to dry the paint quickly and harden the finish.

"All this equipment, and much more, is combined to form our production system. This production system can turn out many automobiles when it's operating smoothly. I install and adjust the equipment to make it operate properly. When something goes wrong with the equipment, the production workers call on me to fix it.

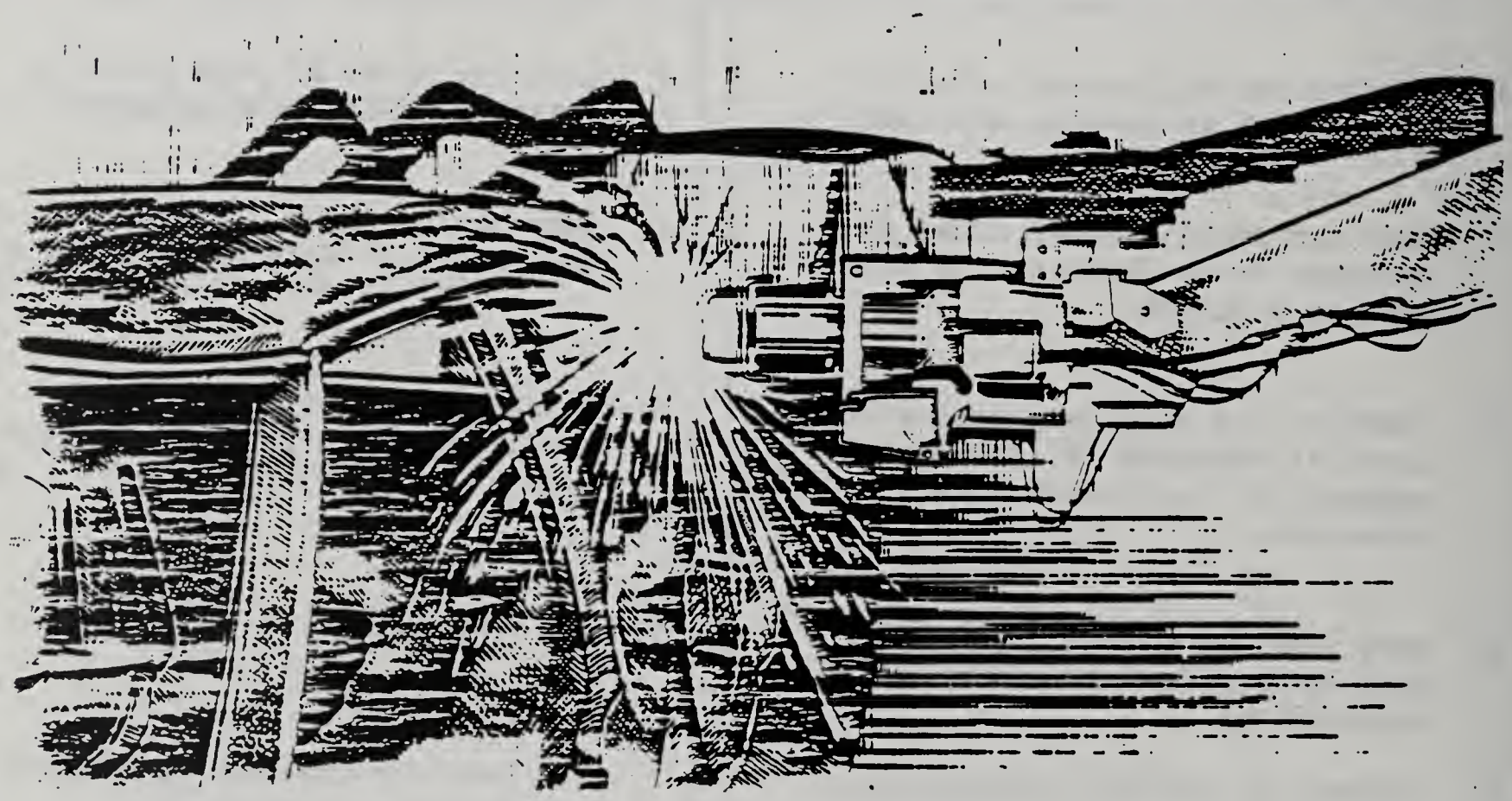


Fig. 2-1 Robot welding operation on auto assembly line.

"The first thing I have to do is troubleshoot the system to find the problem. Sometimes, it's a mechanical problem; other times, it's an electrical, computer or hydraulic problem. Whatever the problem, it's my job to get the system working again.

"If plant equipment doesn't do what it's supposed to, it isn't producing useful work. For instance, if a robot is supposed to move a part to another location but can't, then the robot hasn't done useful work. No matter how much force the robot exerts on the part, if the part hasn't moved (because it is jammed or something is in the way), then work hasn't been done. The same is true if an electrical force (voltage) is applied to a motor, but the motor doesn't turn. The voltage hasn't done useful work. Or if the pressure in the paint lines can't force the paint out (perhaps because the line is clogged), then the pressure hasn't done its work. In other words, things don't always accomplish work just because a force is applied; work is done when the force moves something.

"I like my job because I can see the results of my work. To me, work is getting something done. I can spend a lot of time and effort on a device, but if it doesn't do what it is supposed to do, I don't feel that I've done useful work. When I work on a device and help it run smoothly, both the device and I are accomplishing useful work. That's a good feeling, because this visible proof of my effort makes it obvious that what I do is important."

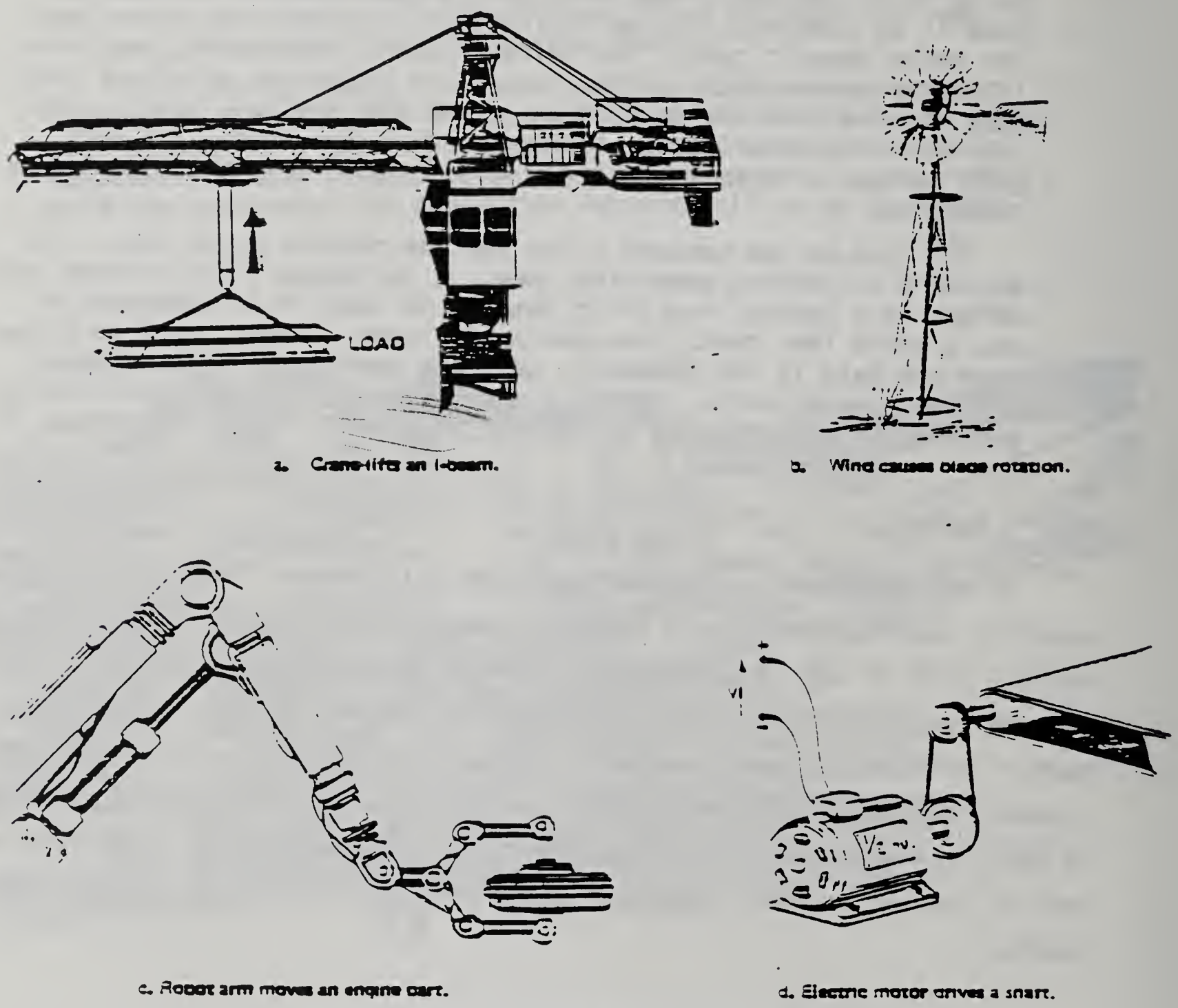
WHAT'S AHEAD?

In the technical sense, work is done only when a **force** or **forcelike** quantity causes something to **move** or **change**. First, we'll look at the easiest kind of work to understand, the **mechanical work** done when forces or torques cause objects to move. Then we'll look at work in other energy systems. In **fluid** systems, pressure does work by moving fluid. In **electrical** systems, voltage does work by moving charge. We'll study practical examples of work in mechanical, fluid and electrical energy systems. And we'll see how the concept of work helps us understand how one energy system affects another.

WHY IS WORK IMPORTANT IN TECHNOLOGY?

One definition of technology is "a collection of methods used to apply energy to do useful work." Useful work takes many forms. It may involve moving steel beams from one place to another, turning the crankshaft of a car, moving water through a pipe, or causing an electric charge to flow

through a wire. In any case, the work done must cause a specific change. The change may be as dramatic as lifting tons of steel--or as invisible as causing a tiny bit of charge to flow in a computer memory. But when work is done, something has to move or change. Complex technology is based on the technician's ability to apply forces and forcelike quantities to do whatever work needs to be done. In Figure 2-2, a crane does work by lifting a steel beam; a robot arm moves an engine part to the assembly line; air movement



a. Crane lifts an I-beam.

b. Wind causes blade rotation.

c. Robot arm moves an engine part.

d. Electric motor drives a shaft.

Fig. 2-2 Work involves forces that cause movement.

controlled by pressure difference in the atmosphere causes the blades of a windmill to turn; and voltage applied to a motor causes the shaft to rotate. These examples illustrate mechanical work being done.

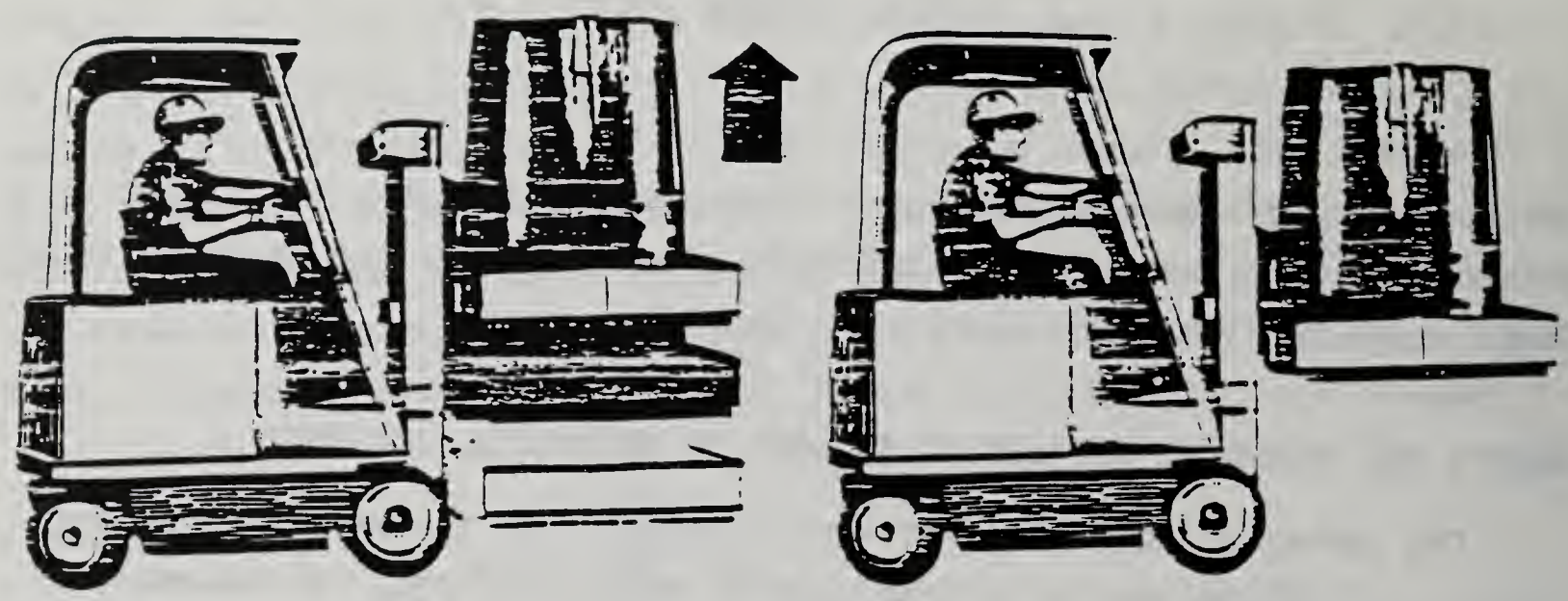
WHAT'S THE TECHNICAL DEFINITION OF WORK IN MECHANICAL SYSTEMS?

The technical definition of work in mechanical systems involves two parts: (1) an applied force that acts on an object, and, (2) movement of that object from one place to another. If you pick up a hammer and lift it over your head, you have done work on the hammer. You are applying a force that causes the hammer to move. If you hold a hammer over your head for a half-hour, without moving it, you do no work. You may get tired, but no work is done because there is no movement. How tired one becomes while applying a force has nothing to do with "work done"—in the technical sense. The amount of work done by a force acting on an object is defined as the force applied in the direction of motion times the distance the object moves while the force is acting. In equation form, work in a mechanical system is written as follows:

MECHANICAL WORK	=	FORCE APPLIED TO OBJECT	X	DISTANCE OBJECT MOVES

Figure 2-3a shows a forklift doing work by lifting a heavy drum. Figure 2-3b shows the forklift holding the drum in a fixed position by applying a force; but in this case, the forklift is doing no work.

Another type of mechanical work is done when a torque causes something to rotate. Examples of rotating objects on which work is done include the wheels of a car, a record player, a power drill for drilling holes, the blades on a helicopter and the gears in an automatic transmission. In these examples, the work done is the forcelike quantity, torque, times the angle



a. Forklift moves a load. b. Forklift holds a load.

Fig. 2-3. A forklift does work only only when it moves something.

through which the object rotates while the torque is applied. In equation form, this activity is expressed as follows:

MECHANICAL WORK	=	TORQUE APPLIED TO OBJECT	x	ANGLE THROUGH WHICH OBJECT TURNS

WHAT ABOUT THE CONCEPT OF WORK IN OTHER ENERGY SYSTEMS?

As you might expect, the concept of work also applies to change produced by forcelike quantities in other energy systems. In a fluid system, a pressure difference causes a volume of liquid or gas to flow from one place to another. The work done in moving the fluid is the product of the pressure difference times the volume of fluid moved. This is written as follows:

FLUID WORK = PRESSURE DIFFERENCE x VOLUME MOVED

In an electrical system, voltage causes charge to move from one place to another. The work done in moving the charge is the product of the voltage and the amount of charge moved. This is written as follows:

ELECTRICAL WORK = VOLTAGE x CHARGE MOVED

Work, then, has been defined as a "force times a distance." Using this definition, how does "pressure difference times volume moved" (work in a fluid system) or "voltage times charge moved" (work in an electrical system) involve a "force" and a "distance?"

In fluid systems, pressure causes fluids to move. Since pressure is a **force** per unit **area**, **force** is involved. Since fluid moves from one place to another, under the push of **pressure**, **distance** is also involved. So "pressure difference x volume moved" in fluid systems is a useful way to calculate "work done." The "applied force" and the "distance moved" are still involved. They are just expressed in a different form.

What about "voltage difference times charge moved?" How does this relate to "force times distance?" This question is not as easy to answer. But if you could see what happens in DC electrical circuits, you would see that electrical forces push electrons through the circuit, from the negative battery terminal back to the positive battery terminal. On a microscopic scale, then, billions and billions of electrons are pushed by electrical forces. So **forces** are involved. As they're pushed, the electrons move from one place to another. So **distance** is involved. It turns out that the equation "voltage times charge moved" is correct--and much easier to use--than "force times distance."

WORK AS A UNIFYING CONCEPT

When the basic concept of work is applied to different systems, it **unifies** our understanding of what happens in each system. Thus, we learn that work is a concept that applies in mechanical, fluid and electrical systems. Work is, therefore, a **unifying concept** that helps us understand mechanical, fluid and electrical systems better.

In Unit 1, we learned about **force** as a unifying concept. We learned that real forces--and **forcelike** quantities--always cause things to move or change. We learned that forces move objects, that torques cause rotation, that pressure moves fluids, that voltage moves charge. We used these analogies to expand and strengthen our understanding of what a force is and does.

In Unit 2, "Work," we study another unifying concept. We've already learned that work in mechanical, fluid and electrical energy systems can be expressed in equation form. These equations are written as follows:

MECHANICAL WORK (LINEAR MOTION)	= FORCE APPLIED x DISTANCE MOVED
MECHANICAL WORK (ROTATIONAL WORK)	= TORQUE APPLIED x ANGLE MOVED THROUGH
FLUID WORK	= PRESSURE x VOLUME MOVED
ELECTRICAL WORK	= VOLTAGE x CHARGE MOVED

We can write ONE equation for work that serves as a pattern for the four equations above. This pattern equation, given below, is a UNIFYING equation for the concept of work.

WORK (UNIFYING)	=	FORCE OR FORCELIKE QUANTITY	x DISTANCE OR QUANTITY MOVED

The force—or forcelike quantity—causes a change in each system. The "distance or quantity moved" is a description of something that moves or changes while work is being done. We sometimes refer to the "distance or quantity moved" as the "displacementlike quantity."

MAIN IDEAS

- Fluids flow naturally from high-pressure to low-pressure regions.
- Fluid systems are either open-type or closed-type.
- Open-type systems move fluids, but do not retain or recirculate fluids.
- Closed-type systems retain and recirculate fluids.
- Work occurs in a fluid system when fluid pressure difference causes liquids or gases to move.

$$W = (\Delta P) \times V$$

- Work occurs in a fluid system when fluid pressure displaces a fluid volume.

$$W = P \times (\Delta V)$$

- Fluid systems interact with mechanical and electrical systems to produce useful work.

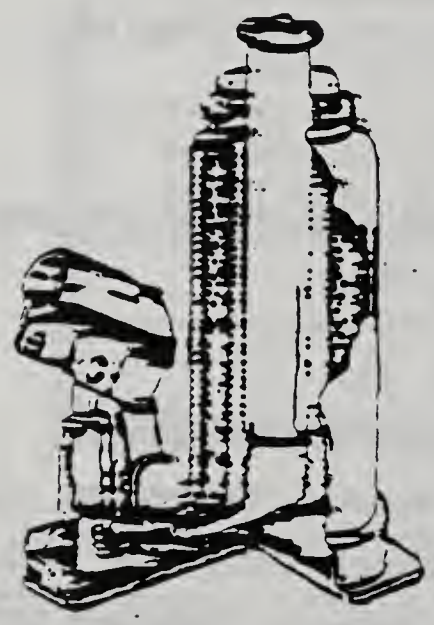
DISCUSSION

In a fluid system, work is done whenever a pressure difference causes liquids or gases to move. Winds blow because air moves naturally from high-pressure regions to low-pressure regions. Work is done by pressure differences that move air as we breathe. When we inhale, we expand our chest cavity and create a region of low pressure inside our lungs. A higher pressure region outside then acts to move air in to fill our lungs. When we exhale, body muscles decrease our lung volume. This increases the air pressure in the lungs and forces the air out. As Figure 2-9 shows, pressure differences cause movement within a fluid system.

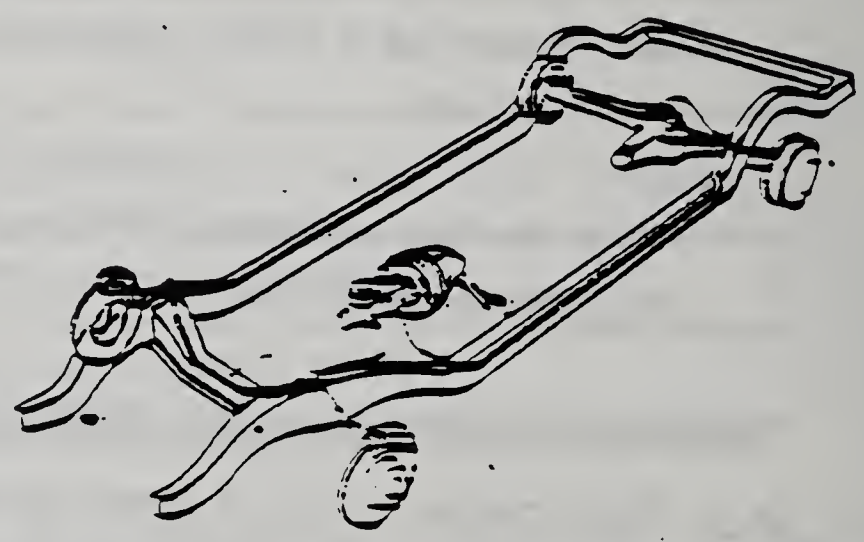
Fig. 2-9 Pressure difference causes fluid motion.

OPEN AND CLOSED FLUID SYSTEMS

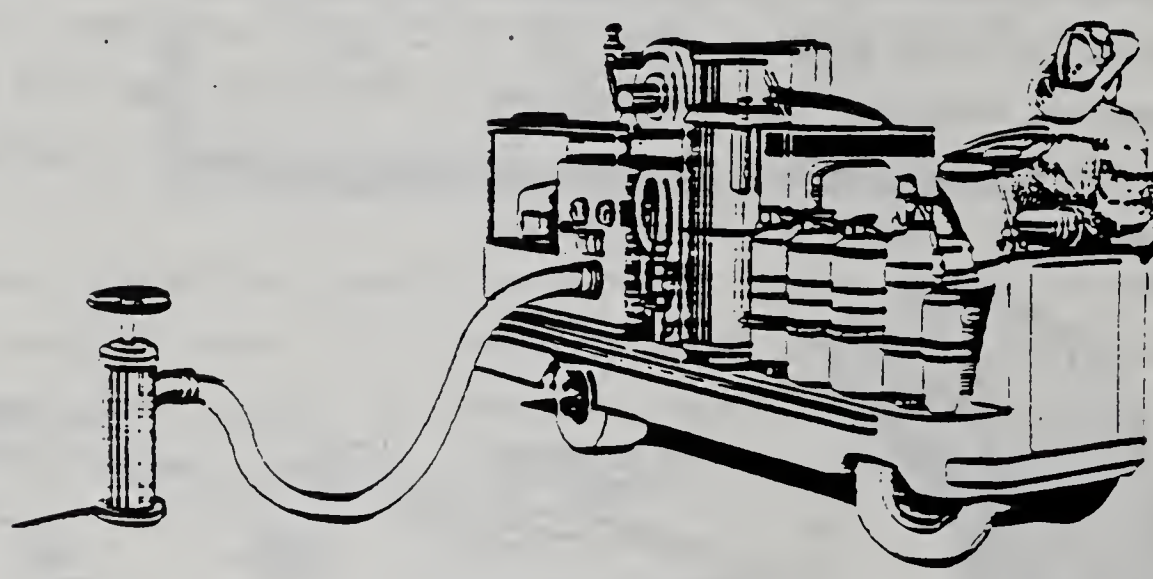
There are two types of fluid systems--open and closed. A closed fluid system is designed to retain and recirculate the fluid. Examples of closed fluid systems include a hydraulic jack, a hydraulic brake system and the body's circulatory system. An open fluid system moves fluids, but does not retain and recirculate the fluids throughout the system. A city water system, an irrigation system or a fire truck water system are examples of open fluid systems. Examples of open and closed fluid system are shown in Figure 2-10.



a. Hydraulic jack (closed)



b. Brake system in car (closed)



c. Firetruck (open)

Fig. 2-10 Open and closed fluid systems.

BASIC HYDRAULIC POWER SYSTEM

A hydraulic power system is used widely in industry and transportation. The basic system, shown in Figure 2-11, is a closed system. It is used to do mechanical work on a load attached to the working piston. Let's examine the different parts and see how they operate together as a system.

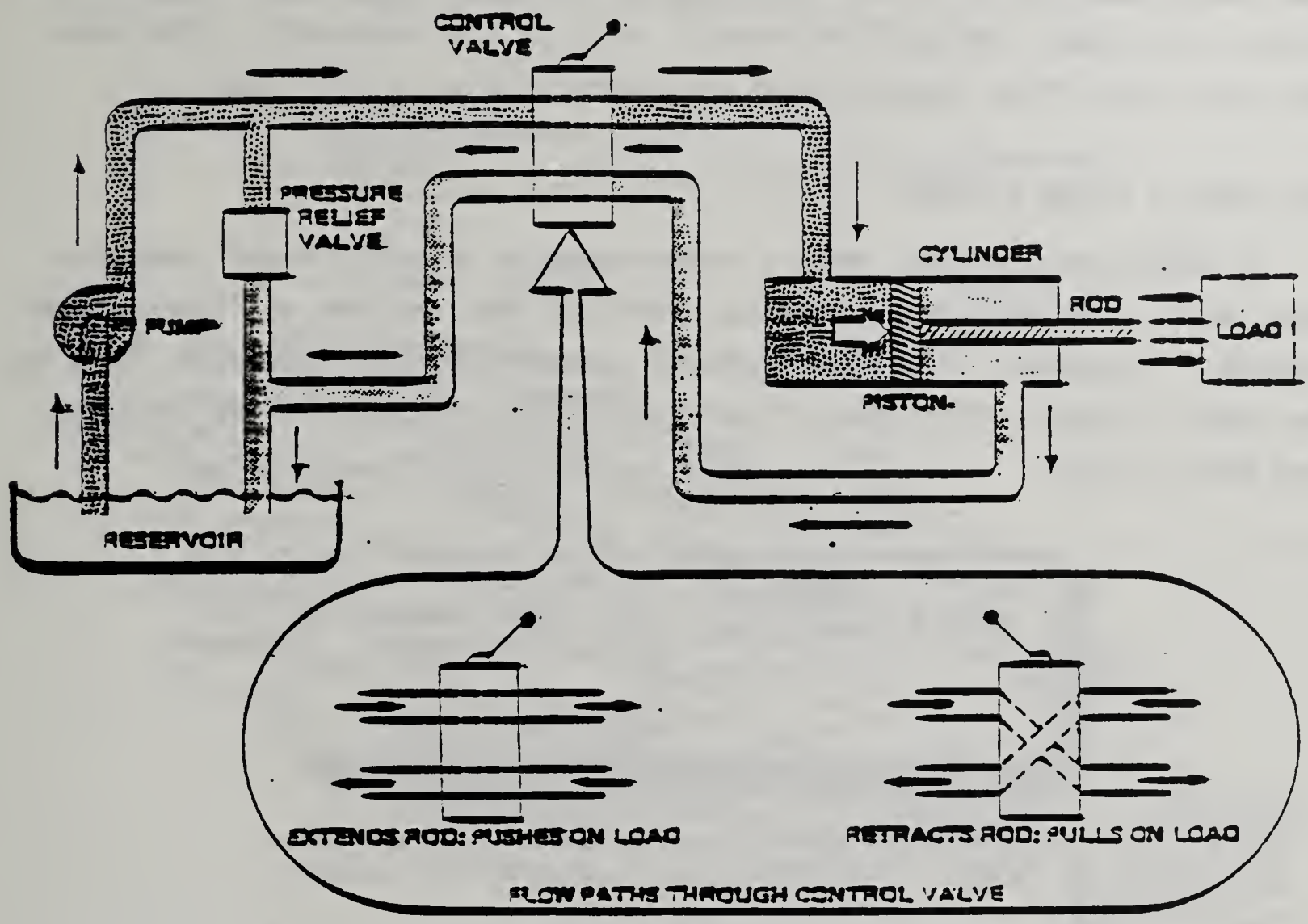


Fig. 2-11 Simple fluid power system.

The pump draws liquid from the reservoir, creates a pressure difference and forces liquid through the pipes under pressure. The pump is driven by a rotating shaft that has been connected to a motor. The control valve is used to direct the liquid to the cylinder to either push or pull on the load. In one position, high pressure liquid flows directly to the left side of the piston, creating a force on the piston that causes the rod to extend or push on the load. (This is the arrangement shown in Figure 2-11.)

In the other position, high-pressure liquid flows directly to the right side of the piston, causing the rod to retract or pull on the load. (Details

of the flow through the control valve are shown in Figure 2-11 for each position of the valve.) In either position, after moving the piston in the cylinder, the liquid is forced out of the cylinder and directed back to the reservoir.

In a third position (not shown), the control valve blocks flow to the cylinder and holds the piston in place. When the control valve blocks the flow, the pressure-relief valve opens automatically. This action allows the liquid in the pump line to flow directly back to the reservoir. This protects the system from damage caused by overpressures in the lines.

WORK DONE IN FLUID SYSTEMS

In mechanical systems, when a force moves an object through some distance, work is done. This mechanical work has been defined as "force times distance." Likewise, in a fluid system, whenever pressure causes a fluid to move, work is done. This type of work is defined in terms of the two equations that follow:

WORK = PRESSURE DIFFERENCE x VOLUME MOVED FROM HIGH PRESSURE TO LOW PRESSURE

$$W = (\Delta P) \times V$$

WORK = PRESSURE x FLUID VOLUME DISPLACED

$$W = P \times (\Delta V)$$

For example, consider the work done by a pump that lifts water from a lake or well to a tank through a vertical distance of "H" feet. (See Figure 2-12.) This type of work is calculated best by using the first equation, $W = (\Delta P) \times V$. The pump moves a certain volume of water (V) through a pressure difference (ΔP). The pressure at the top of the discharge pipe is equal to atmospheric pressure.

The pressure at the bottom, at the inlet pipe, is equal to atmospheric pressure, plus the pressure that comes from the column of water "H" feet high. The pressure difference, from bottom to top, is then equal to the pressure of the water column of height H.

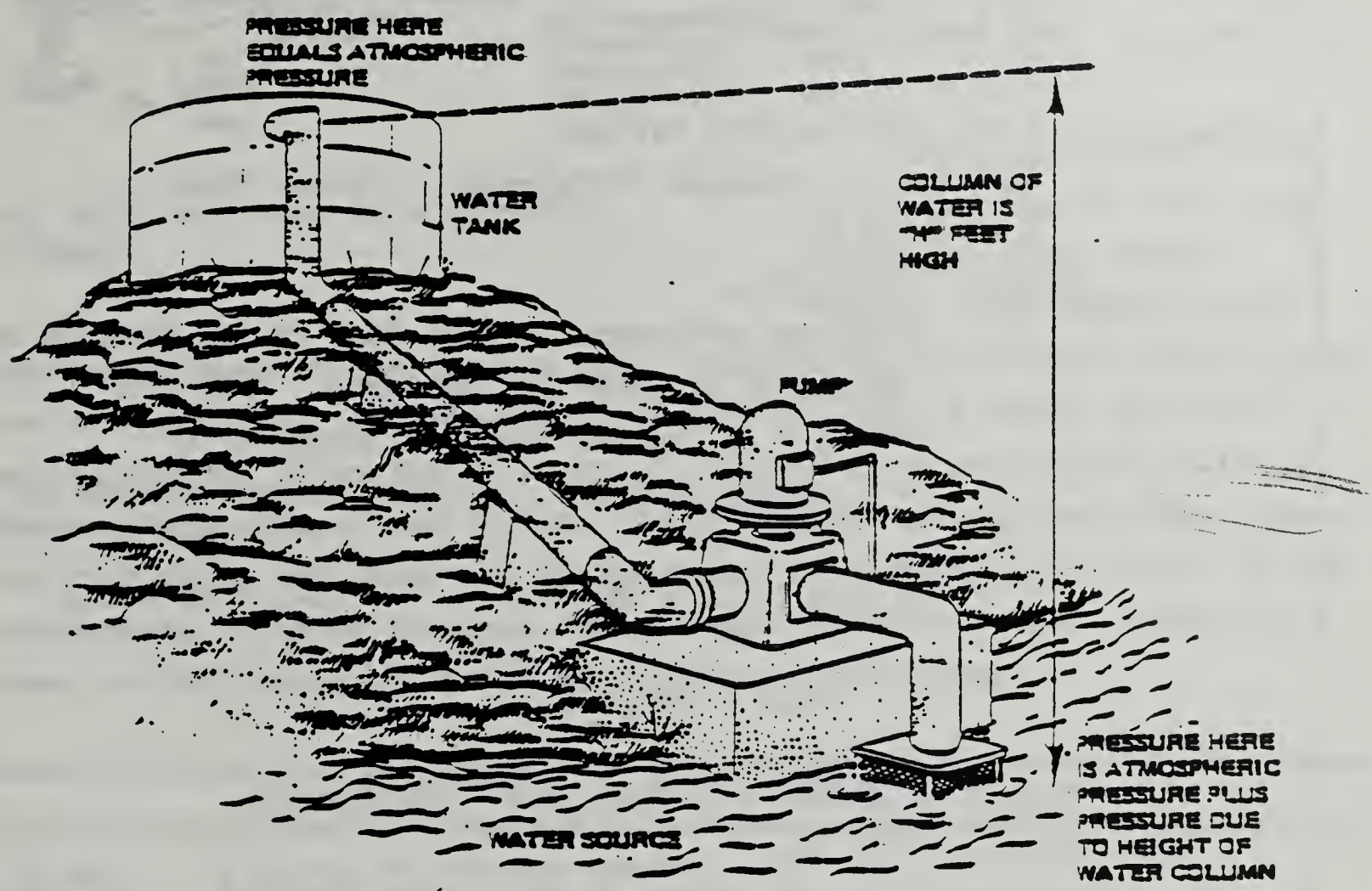
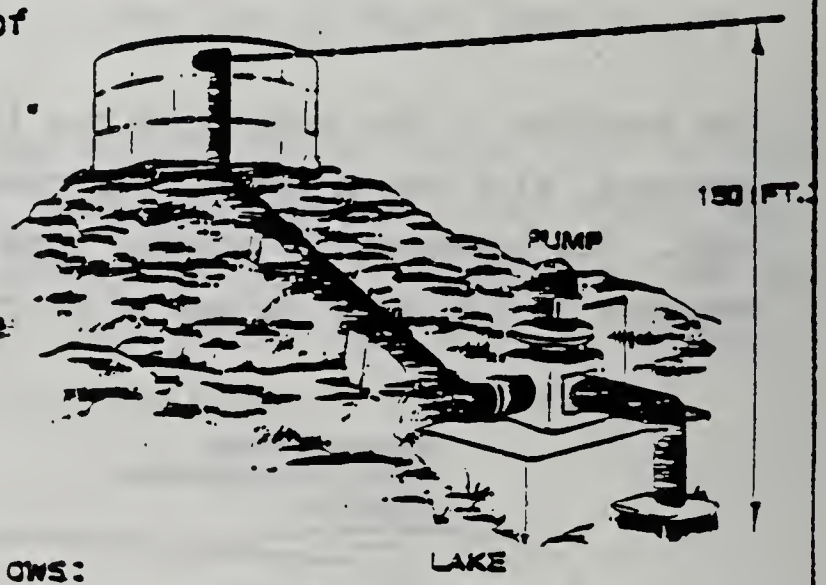


Fig. 2-12 Pump does fluid work in lifting water.

Water systems in rural areas and small cities maintain water pressure by storing water in large tanks 50 to 150 feet above the ground. The tank is filled by pumping water into it from a lake or a well. In Example 2-F, we use the work equation $W = (\Delta P) \times V$ to calculate how much work a water pump must do to fill a 500-cubic-foot tank that is 150 feet above a lake.

EXAMPLE 2-F: WORK DONE BY PUMP TO FILL A TANK

Given: Water tank with a volume of 500 cubic feet (500 ft^3), located 150 feet above water level in a lake. A pump is used to lift the water from the lake to the tank.



Find: Work done by pump to fill the tank.

Solution: Use the equation that follows:

Work Done = (Pressure Difference) x (Volume Moved)

$W = (\Delta P) \times V$

Step 1: Find (ΔP).

Pressure difference (ΔP) is equal to the pressure of the column of water 150 feet high. From Unit 1, "Force," we learned that this pressure is:

P = (Weight density) x height; (Weight density of water is 62.4 lb/ft^3.)

$$P = 62.4 \frac{lb}{ft^3} \times 150 \text{ ft} \qquad \left(\frac{lb}{ft^3} \times ft = \frac{lb}{ft^2}\right)$$

$$P = (62.4 \times 150) \frac{lb}{ft^2}$$

$$P = 9360 \text{ lb/ft}^2 \qquad \text{(This is } \Delta P.)$$

Step 2: Find V.

V is the volume of water moved from the lake to the water tank. It is given as 500 ft^3.

Step 3: Now substitute known values for (ΔP) and V in the equation $W = (\Delta P) \times V$ to find the work done.

$$W = (\Delta P) \times V$$

$$W = \left(9360 \frac{lb}{ft^2}\right)(500 \text{ ft}^3) \qquad \left(\frac{lb}{ft^2} \times ft^3 = ft \cdot lb\right)$$

$$W = 4{,}680{,}000 \text{ ft} \cdot \text{lb}$$

The work done by the pump to move 500 cubic feet of water a distance of 150 feet to fill the tank is 4,680,000 ft·lb.

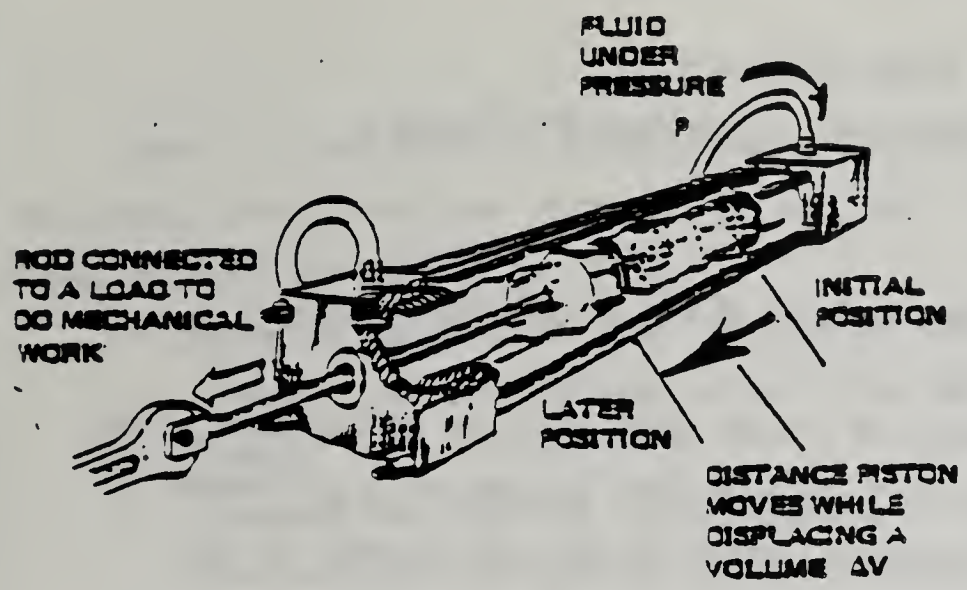


Fig. 2-13 Work done by a hydraulic cylinder.

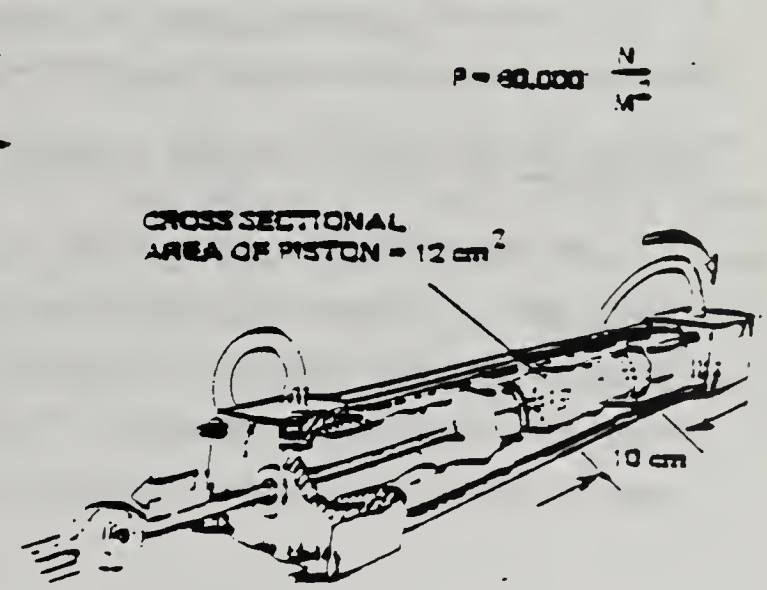
The other equation for fluid work, $W = P \times (\Delta V)$, is used, for example, in calculating the work done by a piston in a hydraulic cylinder. (See Figure 2-13.) Here, the pressure (P), acting on the piston, moves the piston. This movement displaces a volume (ΔV) of fluid.

Heavy-duty robots in industry are used to move large objects or exert strong forces. Such robots use hydraulic cylinders to get the job done. Most hydraulic cylinders (such as the one in Figure 2-13) are made up of a hollow cylinder, a piston and fluid under pressure. Often the fluid is oil, delivered under pressure to the chamber on one side of the piston. The oil pushes against the piston, causing it to move. The other end of the piston is connected to a load. As the piston moves, it moves the load, doing useful mechanical work. Example 2-G shows how work done by a hydraulic cylinder is calculated.

EXAMPLE 2-G: WORK DONE BY A HYDRAULIC CYLINDER

Given: A hydraulic cylinder moves a piston 10 centimeters while pushing on a mechanical load. The fluid pressure on the piston face is 80,000 N/m^2. The area of the piston face (cross-sectional area of the cylinder) is 12 cm^2.

Find: Work done by the hydraulic cylinder while moving the piston 10 cm.



Solution: Use the equation that follows:

Work Done = (Pressure) x (Volume Displaced)

$W = P \times (\Delta V)$

Step 1: Find P.

The pressure P is given as 80,000 N/m^2.

Step 2: Find (ΔV).

The volume of fluid displaced as the piston moves 10 cm is the same as the volume of a cylinder of cross-sectional area 12 cm^2 and length 10 cm.

V = Area x Length

$V = 12\ cm^2 \times 10\ cm$ $\quad (1\ cm^2 \times 1\ cm = 1\ cm^3)$

$V = 120\ cm^3$ (This is ΔV in cm^3.)

Convert ΔV in cm^3 to ΔV in m^3.

$$\Delta V = 120\ cm^3 \times \frac{1\ m^3}{1{,}000{,}000\ cm^3} = 0.00012\ m^3 \quad (\text{Cancel } cm^3\text{'s.})$$

$\Delta V = 0.00012\ m^3$

Step 3: Now substitute known values for P and (ΔV) in the equation $W = P \times (\Delta V)$ to find the work done.

$W = P \times (\Delta V)$

$$W = \left(80{,}000\ \frac{N}{m^2}\right) \times (0.0012\ m^3) \qquad \left(\frac{1}{m^2} \times \frac{m^3}{1} = m\right)$$

$W = 9.6\ N{\cdot}m$

The hydraulic cylinder does 9.6 N·m of work while moving the load attached to the piston a distance of 10 cm.

EXAMPLES OF WORK IN FLUID SYSTEMS

We have studied work done in an open fluid system (filling a city water tank) and a closed fluid system (hydraulic cylinder). We also have studied fluid work done when the intended outcome of the work is (a) to move fluid from one location to another (filling the water tank), and (b) to do some type of mechanical work (hydraulic cylinder).

Useful fluid work is often done--in open or closed fluid systems--simply to move fluids from one location to another. Examples of open fluid systems that do work include:

- movement of natural gas through pipes from supplier to user.
- movement of oil through pipes from wells to refineries (Alaskan pipeline).
- movement of fuel in an automobile from gas tank to carburetor.
- movement of air through ducts in air-conditioning systems.
- movement of water in fire truck pumpers from water hydrants to fire hoses.
- movement of paint in paint-spraying systems.
- movement of water and steam in a coal-fired power plant.
- movement of water from lakes or wells to storage tanks.
- movement of air through compressors in jet engines.

Useful work is also done in closed fluid systems to provide mechanical work. Examples of this type of fluid work include:

- operation of brakes in an automobile braking system.
- use of hydraulic jacks to lift heavy loads.
- use of hydraulic cylinders to push or pull on mechanical loads.

If we look back at the basic fluid power system shown in Figure 2-11, we can see that three different forms of work are involved in the operation of the entire system. Electrical work is done on the motor to operate the pump. The pump, in turn, does fluid work on the liquid to move it through the system. The moving liquid, under pressure, does mechanical work on the piston and load. It is often true, as it is even in this fairly simple system, that several forms of work are being done at the same time. That is why a good understanding of work in mechanical, fluid and electrical systems is important--and it is also why the general idea of WORK as a unifying concept is helpful to our understanding.

SELF-HELP EVALUATION
"WORK"

The following exercises review the main ideas and definitions presented in this subunit, "Work in Fluid Systems." Complete each question as indicated.

1. When work is done by a pump to raise water through a pressure difference, the _____ is multiplied by the pressure difference. (Circle the correct answer.)
   a. fluid weight moved
   b. fluid volume moved
   c. distance fluid moves
   d. weight density of fluid
2. When a moving piston does work in a hydraulic cylinder, the pressure exerted by the piston is multiplied by _____. (Circle the correct answer.)
   a. area of the piston face
   b. fluid volume displaced
   c. weight density of the fluid

Each fluid system in the left-hand column below is classified as either an open fluid system or a closed fluid system. In each of the blanks provided, place the appropriate letter representing the type of system from the right-hand column.

3. ____ city water system	a. closed fluid system	
4. ____ auto fuel system	b. open fluid system	
5. ____ auto brake system		
6. ____ fire department pumper truck		
7. ____ hydraulic jack		

8. The purpose of pumps in fluid systems is to _____. (Circle the correct answer.)
   a. draw fluid from a reservoir
   b. force fluid through a pipe
   c. create a pressure difference
   d. a and b only
   e. a, b and c

9. The work required to lift water from a lake to a tank above the lake is given by $W = (\Delta P) \times V$. To find the pressure difference (ΔP), the _____ _____ of the water must be known, as well as the height (h) of the lift. (Fill in the blank.)

10. To push a box onto a conveyor belt with the shaft of a hydraulic cylinder, a motor-driven pump pressurizes the fluid that operates the piston. This is an example of the general idea of _____ as a unifying concept. (Fill in the blank.)

11. A pump lifts 2 cubic meters of water through a pressure difference of 200,000 N/m^2. The fluid work done by the pump is: (Circle the correct answer.)

    a. 400,000 N/m
    b. 400,000 N·m
    c. 100,000 N/m
    d. 100,000 N·m

12. A hydraulic cylinder displaces 0.25 ft^3 of oil while the piston moves a distance of 1 ft. The pressure on the face of the piston is 60 lb/ft^2. The work done by the hydraulic cylinder while moving the piston 1 ft is: (Circle the correct answer.)

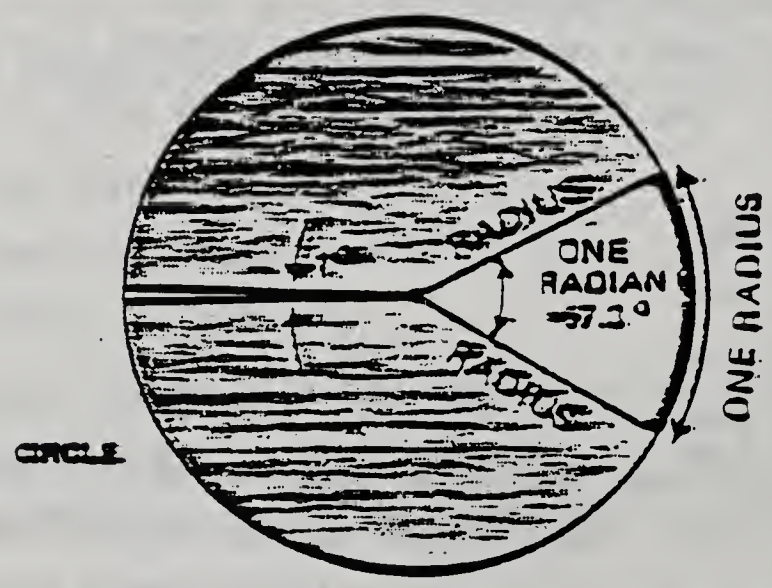
    a. 60 ft·lb
    b. 60 ft/lb
    c. 15 ft·lb
    d. 240 ft·lb

ACTIVITY 1: MEASURING ANGLES IN RADIANS

APPARATUS: For this activity, you will need a protractor and a hand calculator.

DISCUSSION

A. The radian is a unit of angle measure. It is like a degree, only much larger. It is equal to 57.3°. The radian is defined in terms of a piece of a circle. An angle of one radian cuts off an arc on the circle equal to the radius of the circle, as shown below.



B. In terms of revolutions, degrees and radians, we have the following relationships:

1 revolution = 360° (The symbol "°" stands for degree.)

1 revolution = 6.28 radians (abbreviated "rad")

1 radian = 57.3°

C. When changing degrees to radians, multiply angle in degrees by the fraction, $\left(\frac{1 \text{ radian}}{57.3 \text{ degrees}}\right)$. This fraction is equal to <u>one!</u>

Example: Change 90° to radians.

$$(90\ \cancel{\text{degrees}}) \times \left(\frac{1 \text{ radian}}{57.3\ \cancel{\text{degrees}}}\right) = \underline{\underline{1.57 \text{ rad}}} \quad \text{(Cancel degrees.)}$$

Example: Change 287° to radians.

$$(287\ \cancel{\text{degrees}}) \times \left(\frac{1\ \text{radian}}{57.3\ \cancel{\text{degrees}}}\right) = \underline{\underline{5.01\ \text{rad}}} \quad \text{(Cancel degrees.)}$$

D. When changing revolutions to radians, multiply angle in revolutions by the fraction $\left(\frac{6.28\ \text{radians}}{\cancel{\text{revolution}}}\right)$. This fraction is equal to <u>one!</u>

Example: Change 2.5 revolutions to radians.

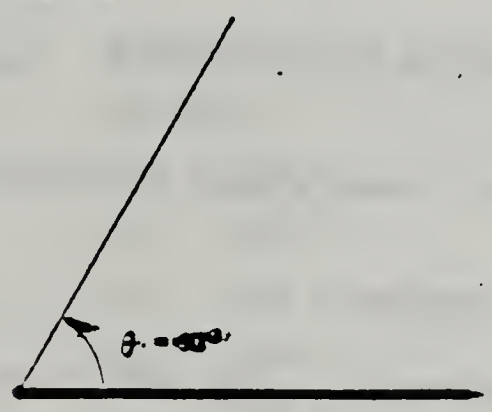
$$(2.5\ \cancel{\text{rev}}) \times \left(\frac{6.28\ \text{rad}}{\cancel{\text{rev}}}\right) = 15.7\ \text{rad} \quad \text{(Cancel revs.)}$$

Example: Change 10 revolutions to radians.

$$(10\ \cancel{\text{rev}}) \times \left(\frac{6.28\ \text{rad}}{\cancel{\text{rev}}}\right) = 62.8\ \text{rad} \quad \text{(Cancel revs.)}$$

E. Measure the following angles with a protractor, and change angle in degrees to angle in radians.

Example:

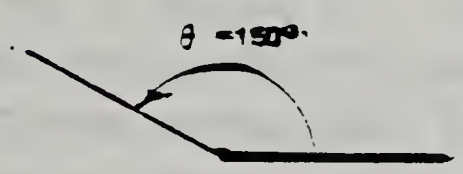


θ measured = 60°

θ in radians is equal to:

$$60° \times \left(\frac{1\ \text{rad}}{57.3°}\right) = \underline{\underline{1.05\ \text{rad}}}$$

Example:



θ measured = 150°

θ in radians is equal to:

$$150° \times \left(\frac{1\ \text{rad}}{57.3°}\right) = \underline{\underline{2.62\ \text{rad}}}$$

PRACTICE EXERCISES FOR ACTIVITY 1

Problem 1: Change each angle in degrees to an angle in radians.

(Remember, 1 radian = 57.3°.)

a. 30° =

b. 57.3° =

c. 360° =

Problem 2: Change revolutions to angle in radians.

(Remember, 1 revolution = 6.28 radians.)

a. 0.5 revolutions =

b. 5 revolutions =

c. 3.2 revolutions =

Problem 3: Draw an angle of 85° with a protractor. What is the angle in radians?

ACTIVITY 2: WORKING WITH PERCENTS

APPARATUS: For this activity, you will need a hand calculator.

DISCUSSION

The word "percent" means "one hundredth." The word "percentage" means "the part of a whole expressed in hundredths."

A. To change a fraction or whole number to a percent, first write the fraction as an equal number of hundredths. This number, with percent (or %) written after it, is the desired answer. For example:

one-half	=	50 hundredths	=	50 percent	or 50%
one-fourth	=	25 hundredths	=	25 percent	or 25%
one (whole)	=	100 hundredths	=	100 percent	or 100%
two (two wholes)	=	200 hundredths	=	200 percent	or 200%
two-fifths	=	40 hundredths	=	40 percent	or 40%

B. To change a decimal to a percent, simply multiply the decimal by 100 and attach the "%" sign. For example:

To change 0.25 to a percent,
0.25 x 100 = 25%; therefore, 0.25 = 25%.

To change 1.20 to a percent,
1.20 x 100 = 120%; therefore, 1.20 = 120%.

PRACTICE EXERCISES FOR ACTIVITY 2

Problem 1: Change each of the following fractions to numbers written as a percent.

a. three-fourths (3/4) =
b. one-fifth (1/5) =
c. two-tenths (2/10) =
d. nine-tenths (9/10) =
e. one and one-half (1 1/2) =

Problem 2: Change each of the following decimals to numbers written as a percent.

a. 0.33 =
b. 0.95 =
c. 0.10 =
d. 1.50 =
e. 0.50 =

ACTIVITY 3: SUBSTITUTING IN FORMULAS

APPARATUS: For this activity, you will need a hand calculator.

DISCUSSION

When a force does work on a machine, such as a pulley or a winch, we call this input work or WORK IN. When the machine does work on something else, such as lifting a weight or hauling a load, we call this output work or WORK OUT. If there is no friction present in any of the turning parts of the machine, WORK OUT = WORK IN. However, for most machines, friction is

present and WORK OUT is less than WORK IN. The percent efficiency of this machine is given by the equation that follows:

$$\% \text{ EFF} = \left(\frac{\text{WORK OUT}}{\text{WORK IN}}\right) \times 100$$

This equation is used to solve a problem in the example below.

EXAMPLE A: CALCULATING EFFICIENCY OF A PULLEY SYSTEM

Given: A block-and-tackle pulley system to lift a weight. The pulley system does 980 newton-meters of work (WORK OUT) to lift a weight. To cause the pulley system to operate, 1000 newton-meters of work (WORK IN) are required.

Find: Efficiency of the pulley system.

Solution: Step 1: Write down the formula for efficiency.

$$\% \text{ EFF} = \left(\frac{\text{WORK OUT}}{\text{WORK IN}}\right) \times 100$$

Step 2: Identify what is given and what needs to be found.

Given: WORK OUT = 980 N•m

WORK IN = 1000 N•m

Find: % EFF

Step 3: Substitute given values for WORK IN and WORK OUT in the formula. Include both the numerical value and the units, as follows:

$$\% \text{ EFF} = \left(\frac{\text{WORK OUT}}{\text{WORK IN}}\right) \times 100$$

$$\% \text{ EFF} = \left(\frac{980 \cancel{\text{N•m}}}{1000 \cancel{\text{N•m}}}\right) \times 100 \qquad \text{(Cancel newton-meters.)}$$

Step 4: Use a calculator to perform the calculation. Write out the answer.

% EFF = 98%

Conclusion: The pulley system is 98% efficient. The difference between 100% and 98% is the work done (wasted) to overcome the friction in the moving wheels of the pulley system.

PRACTICE EXERCISES FOR ACTIVITY 3

Given the formula $\% \text{ EFFICIENCY} = \left(\frac{\text{WORK OUT}}{\text{WORK IN}}\right) \times 100$, solve each system listed below.

Problem 1: Calculate the % efficiency for a block and tackle lifting a load of 600 pounds under the following conditions:

WORK OUT = 1200 ft•lb

WORK IN = 1400 ft•lb

Problem 2: Calculate the % efficiency for a winch hauling in a load of 1000 newtons under the following conditions:

WORK OUT = 3000 N•m

WORK IN = 3150 N•m

Problem 3: Calculate the % efficiency for a "frictionless" pulley system that raises an automobile under the following conditions:

WORK OUT = 3000 ft•lb

WORK IN = 3000 ft•lb

REARRANGING SYMBOLS IN EQUATIONS TO SOLVE FOR UNKNOWNS

DISCUSSION

A. Equations and formulas are used to express a relationship between several physical quantities. Equation 1, which relates the concept of work, force and distance, shows this relationship as follows:

WORK = FORCE APPLIED x DISTANCE MOVED Equation 1

This equation provides a means of determining the value of one physical quantity if the numerical values of the other two are known. Frequently, equations are written with symbols rather than words. Thus, Equation 1, becomes simplified by using the following symbols:

$W = F \times D$ or $W = FD$ Equation 2

where: W = work (newton-meters or foot-pounds)
F = force (newtons or pounds)
D = distance (meters or feet)

B. A technician often must rearrange symbols in an equation to obtain a different form of the same equation. Thus, the equation $P = F/A$ can be rearranged to yield $F = P \times A$ or $A = F/P$. Each of the three forms is correct. Sometimes, one is more useful than the other.

C. To "solve" an equation means to isolate one symbol in the equation. To accomplish this isolation, certain mathematical operations are performed, identically, on both sides of the equation. Any operation performed on one side of the equation always is performed on the other side. Therefore, care must be taken to do the following:

- Add or subtract the same quantity on both sides of an equation.
- Multiply or divide both sides by the same quantity.

Study the examples that follow. They show how to isolate a certain symbol by rearranging the given equation.

EXAMPLE A: REARRANGING SYMBOLS IN W = F x D TO ISOLATE F

Given: $W = F \times D$

Find: F

Solution: Step 1: In rearranging the equation $W = F \times D$ to isolate or "solve" for F, start with the given equation, $W = F \times D$.

Step 2: Divide both sides by D to isolate F.

$$\frac{W}{D} = \frac{F \times \cancel{D}}{\cancel{D}}$$ (The D's cancel out on the right side.)

Step 3: Rewrite the equation with the D's on the right side removed.

$$\frac{W}{D} = F$$ (F has been isolated.)

Step 4: Reverse the order of the equation so that F is on the left.

$$F = \frac{W}{D}$$

The equation $W = F \times D$ has been "solved" for F. The symbol, "F," has been isolated and the correct equation is $F = \frac{W}{D}$.

EXAMPLE B: REARRANGING SYMBOLS IN $W = T \times \theta$ TO ISOLATE θ

Given: $W = T \times \theta$

Find: θ

Solution: Step 1: To solve for θ, start with the given equation,

$W = T \times \theta$.

Step 2: Divide both sides by T to isolate θ.

$\frac{W}{T} = \frac{\cancel{T} \times \theta}{\cancel{T}}$ (The T's cancel out on the right side.)

Step 3: Rewrite the equation with the T's on the right side removed

$\frac{W}{T} = \theta$ (The symbol, "θ," has been isolated.)

Step 4: Rearrange with isolated symbol θ on the left side.

$\theta = \frac{W}{T}$

The equation $W = T \times \theta$ has been "solved" for θ. The symbol, "θ," has been isolated and the correct equation is $\theta = \frac{W}{T}$.

Using Examples A and B as a guide, solve the following four equations by isolating the symbol indicated.

<u>Equation 1:</u> Given: $W = F \times D$

Find: D

Solution:

Equation 2: Given: $W = T \times \theta$

Find: T

Solution:

Equation 3: Given: $W = (\Delta P) \times V$

Find: ΔP

Solution:

Equation 4: Given: $W = P \times (\Delta V)$

Find: ΔV

Solution:

SUBSTITUTING IN FORMULAS

DISCUSSION

A. Care always must be taken to substitute correct numbers and units for known symbols in an equation. Only then can the number and unit of the unknown (isolated) symbol be calculated correctly.

EXAMPLE C: SUBSTITUTING IN THE WORK EQUATION W = F x D TO FIND FORCE

Given: $W = F \times D$ where: $W = 10\ N \cdot m$, $D = 2\ m$

Find: F

Solution: Step 1: Solve for F. (See Example A.) This gives the equation,

$F = W/D$.

Step 2: Substitute given numerical values—with units—for W and D. ($W = 10\ N \cdot m$ and $D = 2\ m$.)

Step 3: Then, $F = \frac{10\ N \cdot \cancel{m}}{2\ \cancel{m}}$. (Cancel m's.)

Step 4: Dividing the numbers and cancelling out meters gives $F = 5\ N$. (The force is 5 newtons.)

8. A good check to make sure that the equation you're using is set up correctly is to check units. Check the units of each physical quantity in the equation. See if they're correct and are equal overall on either side of the equation. Example D shows how to do this.

EXAMPLE D: CHECKING ACCURACY OF EQUATION BY CHECKING UNITS

Given: $W = F \times D$

Find: F

Solution: Step 1: Rewrite the given equation so F is at the left of the equal sign and everything else is at the right. (Refer to Example A if necessary.)

$$F = \frac{W}{D}$$

Step 2: Substitute units for F, W and D in this equation.

$$\text{newtons} = \frac{\text{newton} \cdot \cancel{\text{meters}}}{\cancel{\text{meters}}}$$ (Cancel meters.)

This leaves newtons = newtons. Units "check out."

Therefore, the equation has been set up correctly.

In the problems that follow, you must:

- Isolate the required physical quantity to derive a new formula.
- Substitute the numerical values of the known physical quantities into the formula.
- Check the formula by checking units, as in Example D.
- Solve for the unknown quantity.

***Problem 1:**

Given: $T = F \times L$, where: $T = 20$ lb•ft

$F = 5$ lb

Find: L

Solution: Step 1: Rearrange equation to isolate L.

$$T = F \times L$$

Step 2: Divide both sides of the equation by F.

$$\frac{T}{F} = \frac{\cancel{F} \times L}{\cancel{F}}$$ (F's cancel out on right side of equation.)

$$\frac{T}{F} = L$$ (L has been isolated.)

Step 3: Reverse sides of equation to put L on the left.

$$L = \frac{T}{F}$$

Step 4: Substitute known values for F and T.

$L = \frac{T}{F}$, where $T = 20$ lb•ft and $F = 5$ lb

$$L = \frac{20 \text{ lb}\cdot\text{ft}}{5 \text{ lb}}$$ (Cancel lb units.)

$$L = 4 \text{ ft}$$

Step 5: Check units in equation.

$L = \frac{T}{F}$, where L is in ft; T is in lb•ft; F is in lb.

Therefore, $\text{ft} = \frac{\text{lb}\cdot\text{ft}}{\text{lb}}$ (Cancel lb units.)

ft = ft (Units check; equation is correct.)

---

*This problem has been solved for you. Follow through the solution to make sure you understand each step.

Problem 2:

Given: $W = T \times \theta$, where: $\theta = 6.28$ rad

$W = 62.8$ ft·lb

Find: T

Solution: Step 1: Isolate T in the equation.

Step 2: Reverse sides of equation to put T on the left.

Step 3: Substitute known values for W and θ, and solve for T.

Step 4: Do unit check on equation.

DISCUSSION

In hydraulic cylinders, a liquid under pressure moves a piston. The piston, in turn, moves a mechanical load and does useful work. Similarly, in steam engines, the steam, under high pressure, moves a piston back and forth, doing useful work. In gasoline engines, a piston does work on a mixture of air and gasoline vapor while it compresses the gas into a smaller volume. Figure 1 shows a piston doing work on the gas mixture in an automobile cylinder during the "compression stroke" for that cylinder.

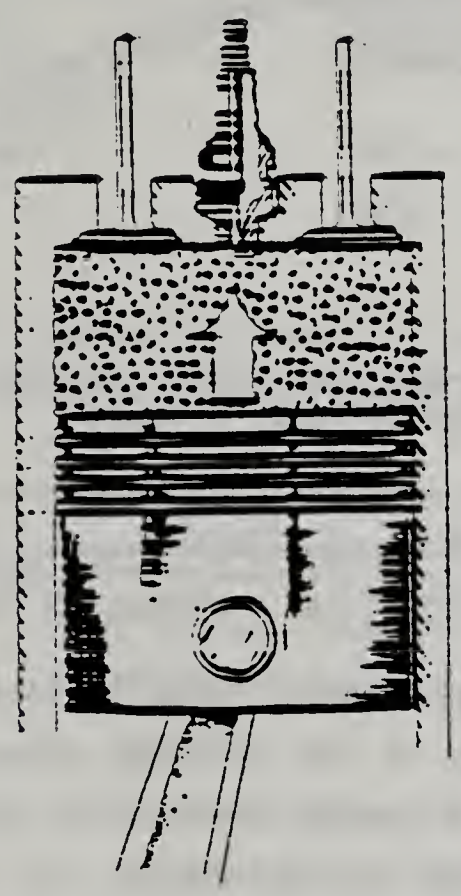


Fig. 1 Piston does work during the gas-compression stroke.

Figure 2 shows a picture of a piston in a steam engine. Steam is admitted alternately, first on one side of the piston, then on the other. This causes the piston to move back and forth in a reciprocating manner.

Reciprocating motion (back and forth) is often converted to circular motion to turn a flywheel for useful purposes.

In this laboratory, we'll study the work done by a piston while it compresses a gas. We will use a simple mock-up of a piston and cylinder arrangement that "squeezes" gas into a smaller volume. We'll find the **WORK DONE** by using the equations $W = F \times D$ (Work = Force times Distance) and $W = P \times \Delta V$ (Work = Pressure times Volume Displaced).

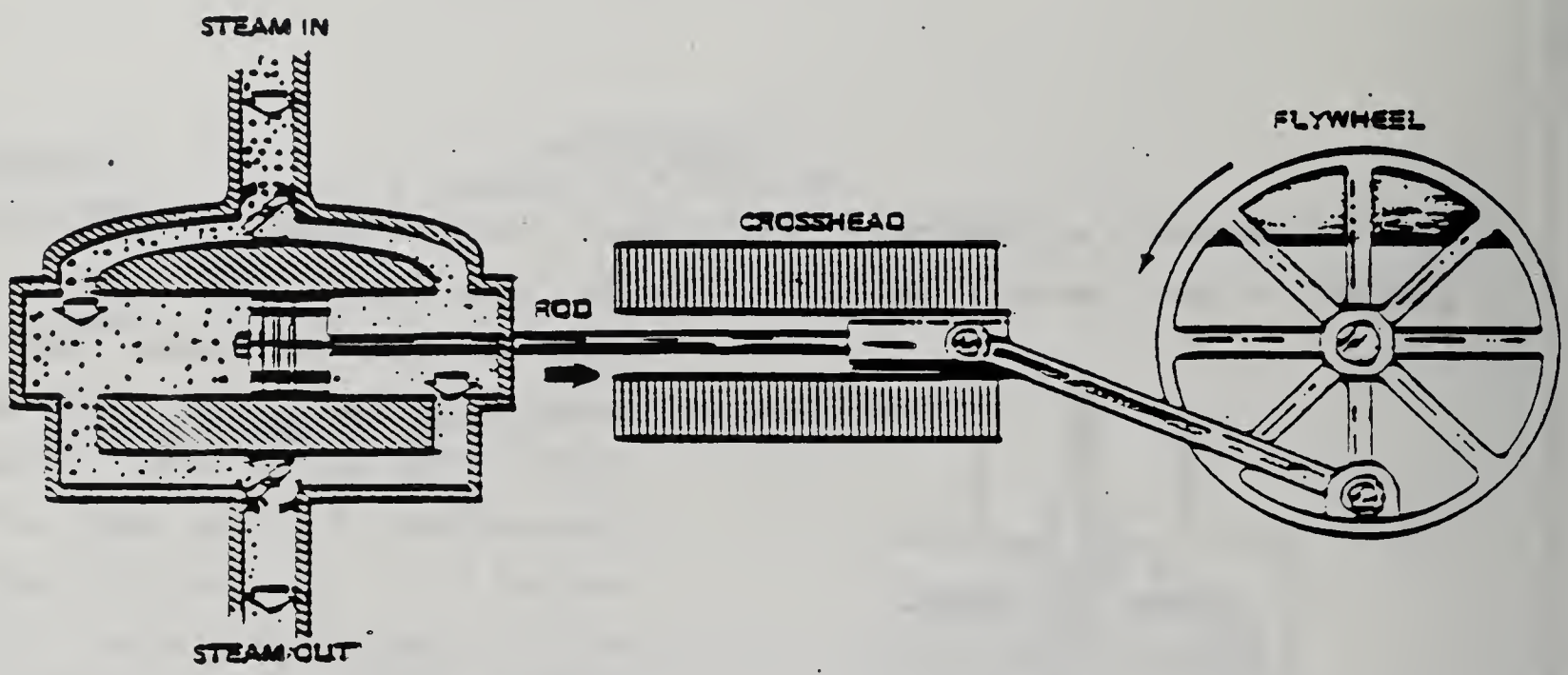


Fig. 2 Steam engine converts reciprocating motion of the piston to circular (rotary) motion of the flywheel.

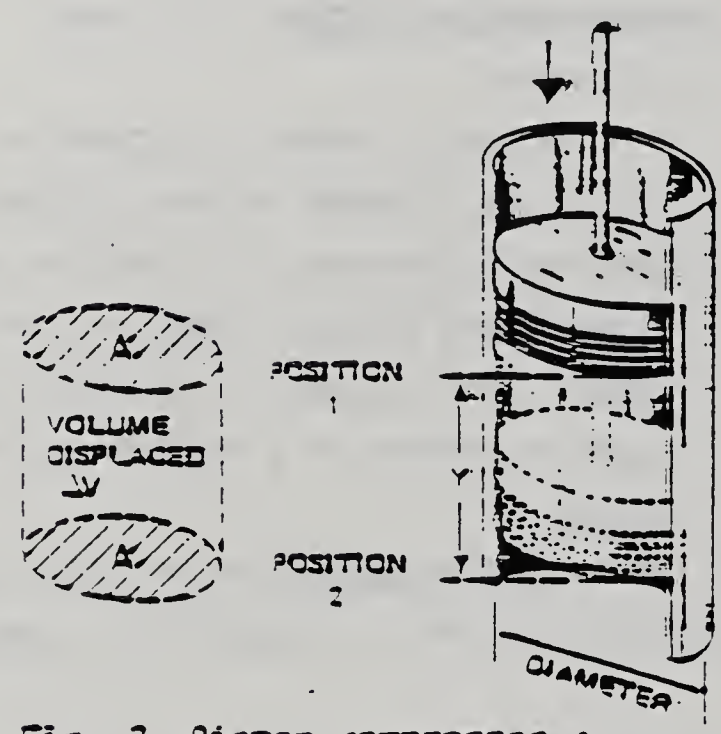


Fig. 3 Piston compresses a gas, changing its volume in the cylinder.

REVIEW:

CALCULATING A CHANGE IN GAS VOLUME

Consider a certain volume of air trapped in the cylinder shown in Figure 3. The piston moves from position 1 to position 2, compressing the air. As the piston is lowered, the volume of the air decreases. The drawing on the side shows the decrease in the volume of the air that is compressed. This decrease in volume is equal to the volume of air displaced by the piston. The exact volume of air displaced can be determined by calculating the volume of a cylinder of height Y and base area A. Base area A is equal to the area of a circle of diameter D. The area of a circle of diameter D is given by $0.7854\ D^2$.

Therefore, the change in gas volume or volume displaced as the piston moves down a distance Y is as follows:

$$(\Delta V) = \begin{pmatrix}\text{CROSS-SECTIONAL}\\ \text{AREA OF CYLINDER}\end{pmatrix} \times \begin{pmatrix}\text{DISTANCE}\\ \text{PISTON}\\ \text{MOVES}\end{pmatrix}$$

$$(\Delta V) = (0.7854\ D^2) \times (Y)$$

$$(\Delta V) = 0.7854\ D^2 Y \qquad \text{Equation 1}$$

Knowing values for D and Y, one can find the change in air volume by substituting these values in Equation 1. Example A shows how to do this.

EXAMPLE A: CALCULATING VOLUME OF AIR DISPLACED	
Given:	A piston such as the one shown in Figure 3 moves a distance of 2.0 inches in a cylinder where the inside diameter is 4.0 inches.
Find:	ΔV—the volume of air displaced by the piston (or change in volume of the compressed air).
Solution:	Use Equation 1.

$\Delta V = 0.7854\ D^2 Y$ where: $D = 4.0$ inches, $Y = 2.0$ inches

Substitute D = 4.0 inches and Y = 2.0 inches in the equation, as follows:

$\Delta V = 0.7854\ (4\ \text{in})^2\ (2\ \text{in})$

$\Delta V = 0.7854\ (16\ \text{in}^2)(2\ \text{in})$ (Use a calculator.)

$\Delta V = 25.13\ \text{in}^3$ ($\text{in}^2 \times \text{in} = \text{in}^3$)

The piston displaces 25.13 cubic inches of air. The decrease in volume of the trapped air must be equal, also, to 25.13 cubic inches.

SELF-HELP EVALUATION #3

WORK IN FLUID SYSTEMS

COMPLETE THE STATEMENTS BELOW:

1. Name two advantages for pneumatics _____ and _____.

2. Boyles Law states that volume varies _____ as its absolute pressure.

3. Rising temperature causes gases to _____.

4. Pneumatic and electrical systems use similar expressions for doing work.

   Pneumatic work formula _____.
   Electrical work formula _____.

5. Open fluid systems do not make provision for _____.

6. A sump pump lifts 2 cubic meters of water through a pressure difference of 200,000 N/M (squared). The work done by the pump is _____.

INTERMEDIATE OBJECTIVE #3

Describe the rate of fluid flow in the fluid system.

LEARNING STEPS (Activities)

1. Read inforamtion sheet cited in Resource #3 to study an overview of rate.
2. Complete the self-help evaluation cited in Resource #2 to assure your mastery of thsi subject.
3. Perform the activities cited in Resource #3 to evaluate your math skills.
4. Proceed to the next Intermediate Objective.

RESOURCES

1. Information Sheet #5 pages 46 - 56 entitled "Rate in Fluid Systems".
2. Self-help evaluation #2, page 57 entitled "Rates."
3. Activity Sheet #6 pages 59 - 67 entitled "Math Skills II".
4. The next Intermediate Objective begins on page 68.

INFORMATION SHEET #5
RATE IN FLUID SYSTEMS

DISCUSSION

THE UNIT AND SUBUNITS

Unit 3, "Rate," includes a unit overview (which you are now reading) and four subunits. The subunits are:

- Rate in Mechanical Systems—speed, velocity and acceleration
- Rate in Fluid Systems—volume flow and mass flow
- Rate in Electrical Systems—electrical charge flow or current
- Rate in Thermal Systems—heat flow per elapsed time

You will learn about rate by reading this text, watching video programs, listening to your instructor, participating in class discussions, watching and/or performing demonstrations, and completing eight laboratory exercises.

WHAT IS RATE?

Rate is the relationship between a displacementlike quantity and an elapsed time. Rate always involves how slow or how fast something changes—or how slow or how fast something happens. For example, the rate at which you read the pages in this unit can be determined by dividing the number of pages (displacementlike quantity) by the time (elapsed time) it takes you to read them. If you read seven pages in seven minutes, your reading rate is one page per minute.

Rate is computed by dividing the displacementlike quantity by the elapsed time that it takes for the displacement to occur.

$$\text{RATE} = \frac{\text{DISPLACEMENTLIKE QUANTITY}}{\text{ELAPSED TIME}}$$

Within the four energy systems, the displacement quantities are very different. In mechanical systems, the displacementlike quantity is a distance (mile or meter) or an angle (radians or revolutions). In fluid systems, the displacementlike quantity is a volume (cubic feet) or a mass (kilogram). In electrical systems, the displacementlike quantity is a charge (coulomb). And in the thermal system, it's an amount of heat energy (calories or British thermal units). Although the displacementlike quantities are different, all clearly meet the requirements of the definition for rate.

In this unit, rate will be discussed in all four systems. For example, both the speed of an automobile in miles per hour—or the rotational speed of an electric drill in revolutions per minute—are examples of **mechanical rates.** **Fluid rates** include the measurement of the pulse rate in beats per minute and the output of an oil well in barrels per day. Likewise, the output of an air compressor, measured in cubic feet per minute (or m^3/min), is also a fluid rate. **Electrical rates** occur in the output of a radar signal in electrical pulses per second—or the tuning of an FM radio in cycles per second (or hertz). **Thermal rates** are involved in the heating process of a furnace and during the cooling process done by an air-conditioner. Thermal rates are measured in calories per second or British thermal units per hour. (See Figure 3-1.)

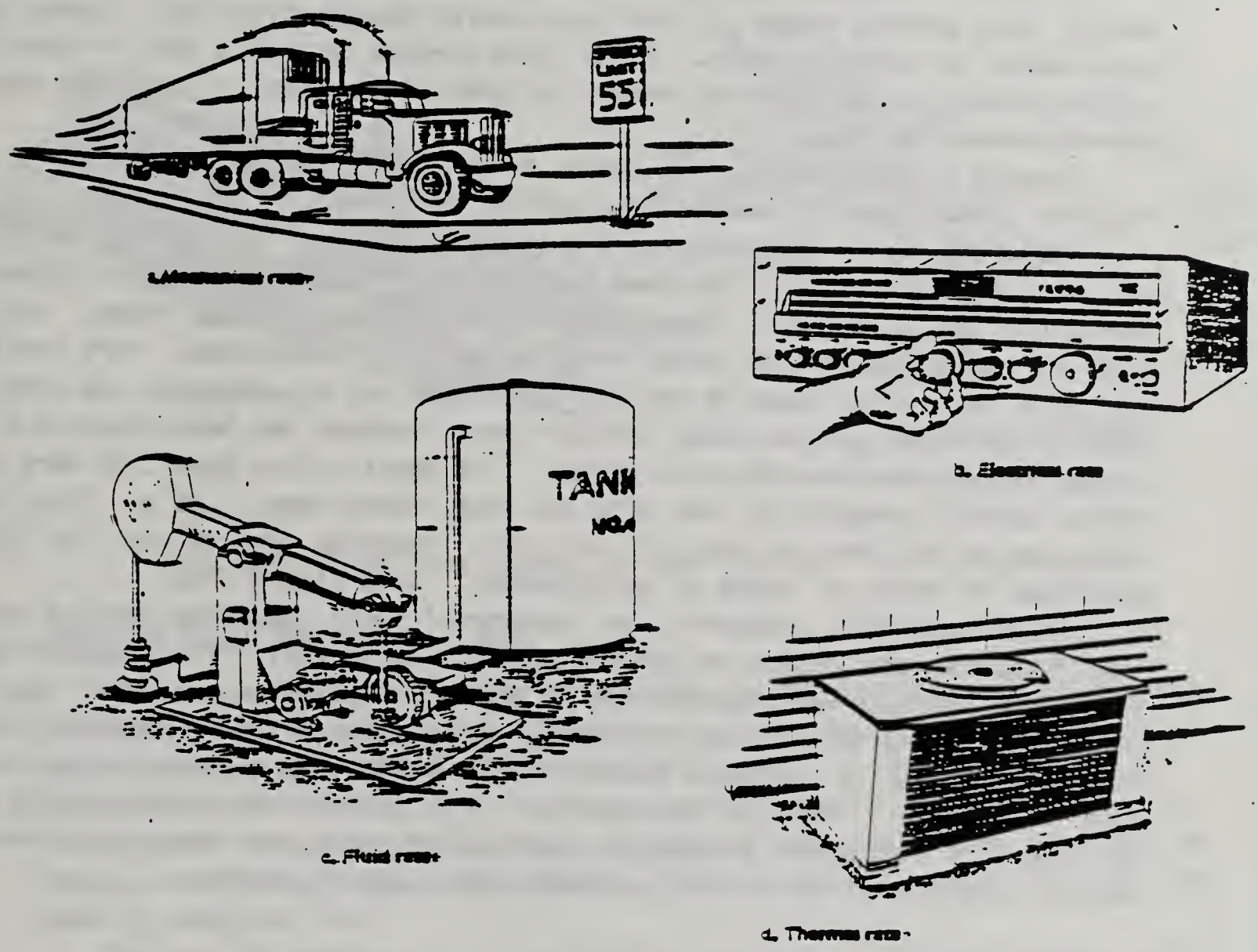


Fig. 3-1 Rate in the four systems.

A knowledge of rate is important to technicians because rate is an integral part of the industrial realm. In fact, after reading Unit 3, you'll begin to understand that a technician could not operate, maintain, troubleshoot, repair, build or adapt equipment without an understanding of how rate operates in the four energy systems. That's why rate is a unifying concept in the Principles of Technology.

RATE IN THE FOUR ENERGY SYSTEMS

HOW IS RATE USED?

In Unit 1, "Force," you learned that forces can cause an object to start moving, stop moving, speed up, slow down and/or change direction. Forces can also change an object's shape. Since "time marches on" while any of these actions occur, we can describe events in terms of how fast or slow they happen—by measuring rate.

Rate is a general term. We define it by using time as one of the factors. Rates usually measure how fast or how often.

Rates can vary. For example, the speed of light is 300 million meters per sec (186,000 mi/sec). The feed rate on a drill press is about 4 inches per minute (10.16 cm/min). There are big differences in these rates. But both are rates that can be useful information for a technician. More familiar rates may be the speed of the bus that takes you to school or the rate at which a sprinkler applies water to your lawn. Perhaps you have observed a street repair crew resurfacing a street. The machine that does this work can spread asphalt pavement 10 feet wide and four inches deep (3.05 m x 10.16 cm) at a rate of 300 feet per hour (91.44 m/hr). Machines that do work are often described in terms of "rates of performance." (See Figure 3-2.)

In the business, commercial and industrial world, machines perform critical functions that depend on perfect timing. Mechanical, fluid, electrical and thermal systems—or combinations of these systems—compute, move, cut, lift, weld, bore, thread, saw and paint. Each system involves separate rates that are designed to provide a smooth flow of work. The combined rates result in an overall rate for the activity. This overall rate might end up as the number of newspapers printed per day, dollar sales per month—or a production rate for anything from cardboard containers to Learjets.

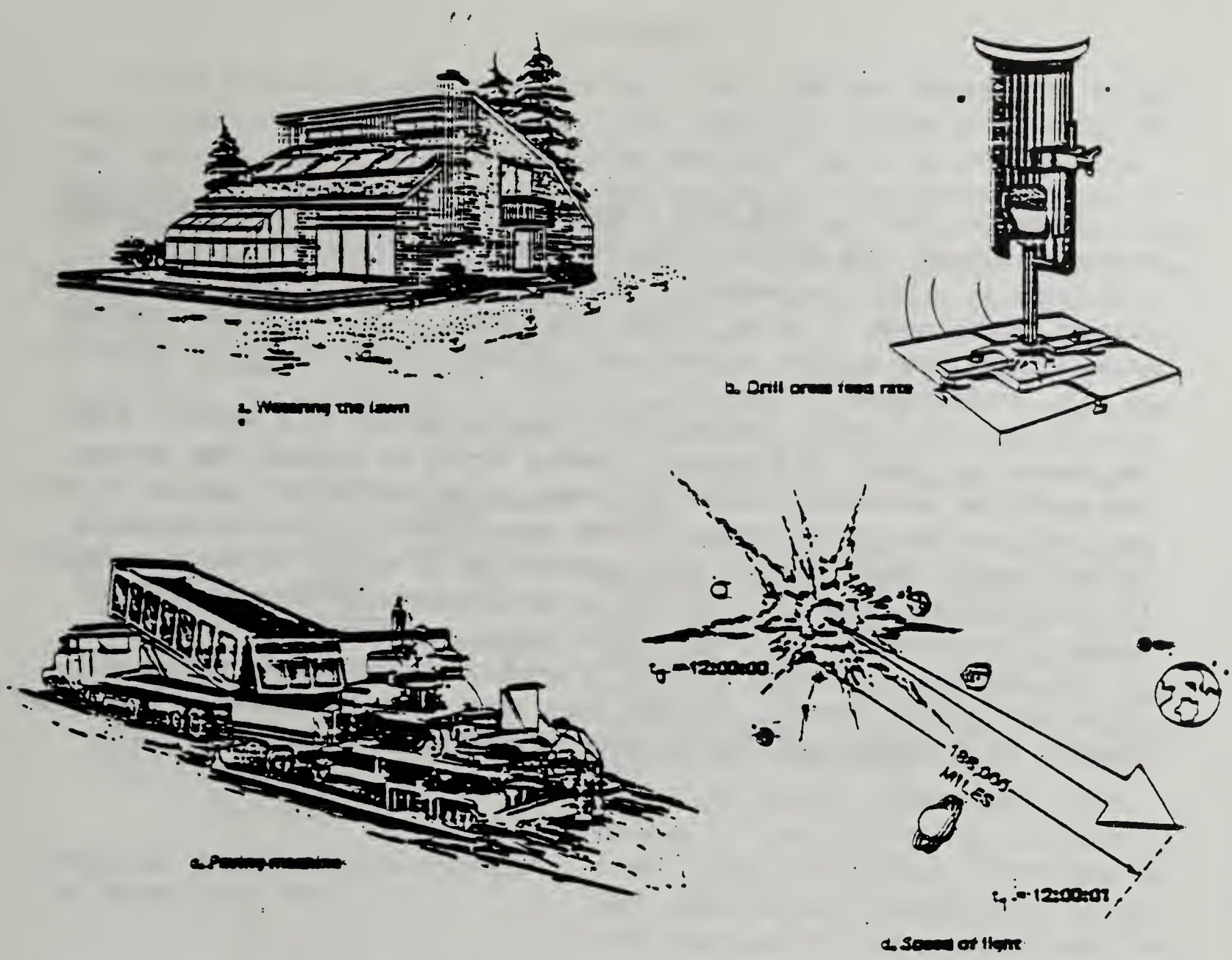


Fig. 3-2 Rates vary depending upon the activity taking place.

TYPES OF RATES AND UNITS OF RATE

Earlier, examples of rates in the four energy systems were given, such as the speed of an automobile, the rate of a heartbeat, the frequency of a radar signal or the output of an air-conditioner. In each case, rate expressed the relationship of a displacement like quantity to an elapsed time. The physical units used to express rate depend upon the system of units you choose. Both the System International (SI) and English system of units are used to describe rate.

The rate of movement of an automobile involves a distance covered during an elapsed time period. This rate is commonly called "speed." Speed is measured in miles per hour or kilometers per hour. Speed is a rate in a mechanical energy system.

Likewise, the flow rate from a sprinkler involves a volume displacement during an elapsed time period. Flow is a rate in a fluid energy system. Fluid rate is usually expressed as gallons or liters per minute. We can also express liquid rates in terms of mass flow rates. This is possible because given liquids have a known mass-per-unit volume. Volume is easily converted to mass, as we learned in Unit 1.

In electrical energy systems, the electric current in a motor is simply the charge (or number of electrons) flowing during an elapsed time period. The electrical pulses per second of a radar signal is another example of the application of electrical rate. Thermal energy rate involves the movement of heat energy from regions of high temperature to regions of low temperature in a certain time interval. The rate at which operating machines can be cooled is important to the proper operation of a machine.

In summary, the concept of rate is present in mechanical, fluid, electrical and thermal systems. In each case, rate is an expression of the relationship of a displacementlike quantity to an elapsed time.

DISCUSSION

Fluid systems are common in everyday life. They are common also in commercial and industrial applications. With each fluid system that is operating, there is usually an important fluid rate that has to be controlled or measured. For example, the fan in a heating and air-conditioning system is designed to take stale air from a room, then condition, filter and return the air to the room either as warm air or cool air, depending on the season. The amount of air moved is a rate measured in either cubic meters per minute (m^3/min), or cubic feet per minute (ft^3/min)—or cubic feet per hour (ft^3/hr) in large systems. Fluid rates control how fast a shower or faucet runs; how comfortable a home, office or plant is maintained; and the ease of operation of a car. Many industrial or manufacturing machines also depend on fluid rates.

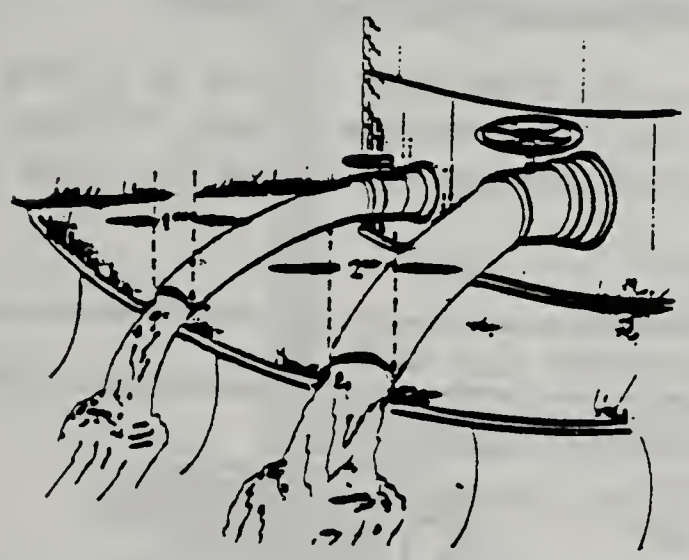


Fig. 3-8 Effect of pipe diameter on volume flow rate.

At first glance, it's tempting to say that rate in fluid systems can be described as a measure of fluid speed. However, fluid rate is involved with volume of flow. Examination shows that if fluid speed in two pipes of different size is the same, less volume of fluid will flow through a small pipe than through a large pipe during the same time. (See Figure 3-8.) This means we must take volume or capacity of fluid into consideration when describing flow rate. Simply stating fluid velocity does not adequately describe flow rate.

VOLUME FLOW RATE

A common rate in fluid flow is called "volume flow rate." This rate is found by dividing a measured volume of fluid moved by the time required for this volume of fluid to flow from a pipe. The fluid moved is often referred to as the displaced fluid. Using a word equation, volume flow rate can be expressed as:

$$\text{VOLUME FLOW RATE} = \frac{\text{VOLUME OF FLUID DISPLACED}}{\text{ELAPSED TIME}}$$

Using symbols, volume flow rate can be written as;

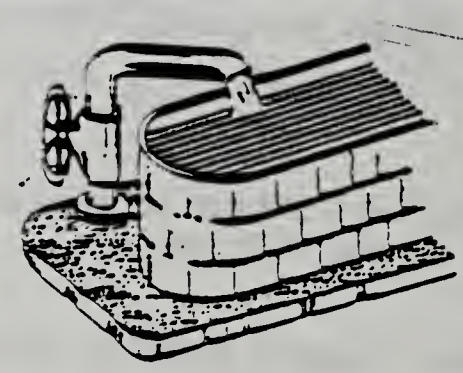
$$Q_V = \frac{V}{t}$$

where: Q_V = volume flow rate
V = volume of fluid moved
t = time of movement

Volume flow rate has many units. Any volume unit divided by a time unit meets the definition. Common volume flow rates include m^3/sec, ft^3/sec, gal/min, liters/sec, etc. Example 3-F illustrates how volume flow rate is determined.

EXAMPLE 3-F: VOLUME FLOW RATE

Given: A tank holds 10,000 gallons; four hours (240 min) are needed to fill the tank at a steady rate.



Find: Volume flow rate of water through the pipe.

Solution:

$$Q_V = \frac{V}{t}$$

$$= \frac{10{,}000 \text{ gal}}{(4 \text{ hr}) \cdot \left(\frac{60 \text{ min}}{1 \text{ hr}}\right)} \quad \text{(Cancel hr units.)}$$

$$= \frac{10{,}000 \text{ gal}}{240 \text{ min}}$$

Q_V = 83 gal/min; the steady volume flow rate required to fill the tank is 83 gallons each minute.

MASS FLOW RATE

When the fluid is gas (and sometimes liquid), it's often desirable to consider mass flow rate rather than volume flow rate. Mass flow rate is defined as the fluid mass moving past a given point or position in a given amount of time. Stated in equation form, this rate is written in the following manner:

$$\text{MASS FLOW RATE} = \frac{\text{MASS OF FLUID DISPLACED}}{\text{ELAPSED TIME}}$$

or, written simply,

$$Q_m = \frac{m}{t}$$

where: Q_m = mass flow rate
m = mass of fluid moved
t = time of movement

Example 3-6 demonstrates how mass flow rate can be determined.

EXAMPLE 3-6: MASS FLOW RATE

Given: 180 kg of ammonia gas flowing through the cooling coils of a refrigerated truck in 6 minutes.

Find: Mass flow rate of the gas.

Solution:

$$Q_m = \frac{m}{t}$$

$$Q_m = \frac{180 \text{ kg}}{6 \text{ min}}$$

$$Q_m = 30 \text{ kg/min}$$

The ammonia gas is flowing at a rate of 30 kg/min; or, since one kilogram equals 1000 grams, at the rate of 30,000 grams/minute.

MEASURING FLUID RATES

As we have seen, the commonly-used rates for fluid are volume flow rate (Q_v) and mass flow rate (Q_m). Methods for measuring and controlling these two rates vary, depending on the situation. Instruments for reading or determining these rates include direct indicators such as flowmeters (which operate on displacement or movement of the fluid) and indirect indicators for pressure and velocity (which allow flow rate calculations to be made with great accuracy).

CONTROLLING RATES OF FLUID SYSTEMS IN WORKPLACE APPLICATIONS

Workplace applications where fluid system rates are measured include bottling plants for any number of products, from soft drinks to dishwashing liquid. (See Figure 3-9.) In these applications, a pump moves the fluid from a mixing tank to a bottling machine. The rate of flow is set so that the bottles are filled as the conveyor belt moves them into position.

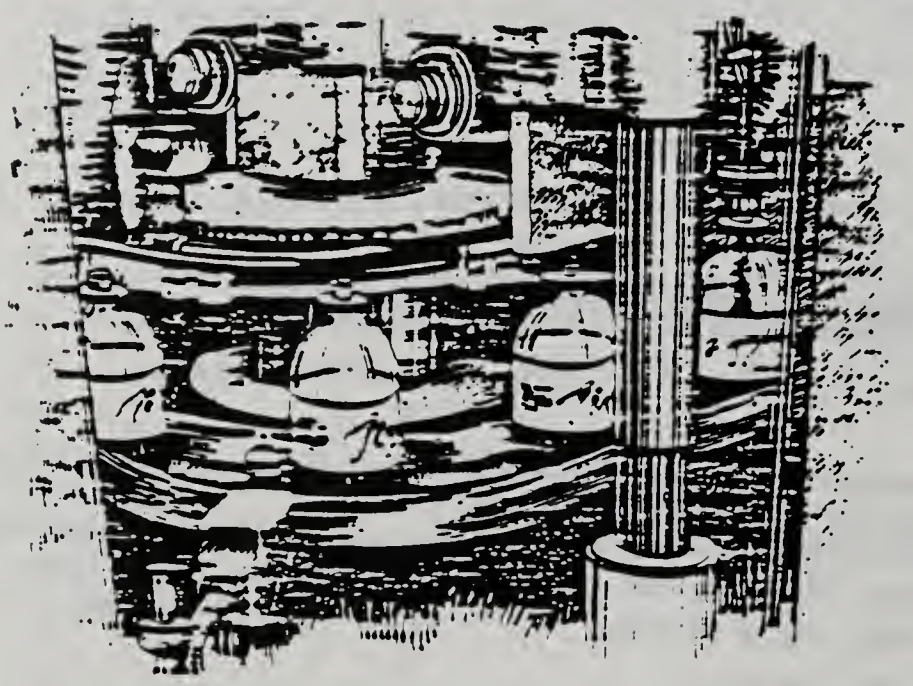


Fig. 3-9 Production rate.

The city water purification plant treats water before introducing it into the supply system. Aeration nozzle ratings in gal/min, or pump capacity in liters/sec, determines the aeration treatment time for the water. This rate is linked directly to the volume flow rate, as well as to the ability of the water system to serve the community.

If the volume flow rate is high, the system must have large pipes that make water available where needed without having to move it rapidly over long distances. Using smaller pipes and higher flow speeds might also meet the demand. But the work required to move the same amount of water through smaller pipes would be higher and, thus, less efficient. (See Figure 3-10.)

Fig. 3-10 A city water treatment system where rate is important.

In the case of gases (especially air, which is in common use), it's necessary to locate the storage tank as close to the point of use as possible. Since air is compressible and is greatly influenced by temperature, traveling long distances through lines at high speeds causes high frictional losses. Locating the compressor and storage tank close to the point of use makes it easier to maintain the volume flow rates of the system. (See Figure 3-11.)

Firefighters and persons who operate earthmoving equipment are dependent on hydraulic systems to help them perform their heavy work tasks. In earthmoving equipment, the rate of flow of fluids into or out of the equipment's hydraulic cylinders determines how many cubic feet (or cubic yards) of earth or rock can be moved per hour by the machine. In firefighting, both the pumping capacity and nozzle rating of the fire truck and equipment determine how many gallons of water per minute can be placed on a fire. Pumping capacity of fire trucks also determines how high the stream of water can be raised above street level. For tall buildings, this may be many stories high. Having the proper amount of water pressure is crucial to the task of fire fighting. (See Figure 3-12.)

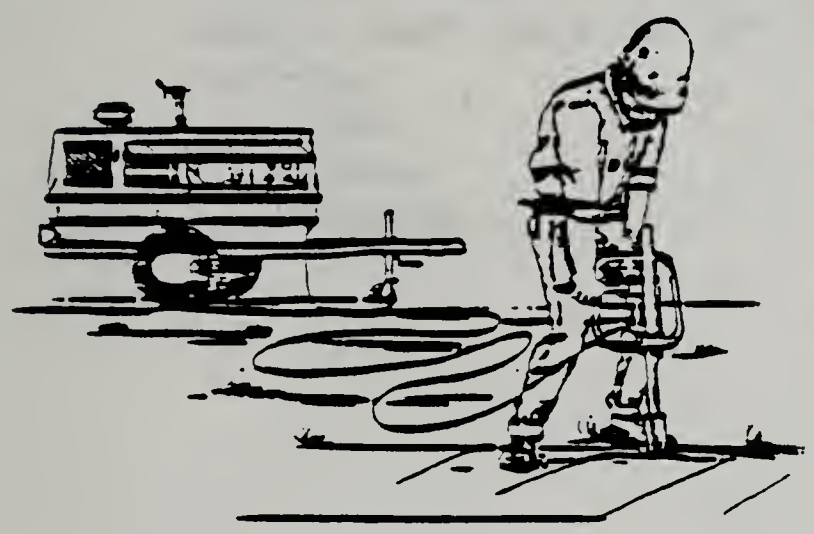


Fig. 3-11 Control of flow rate from air compressor to jackhammer is important.

Fluid systems with various flow rate controls are used in plants, commercial and industrial locations to move materials, operate conveyors, and lift and lower elevators. Rate of flow of fluids is an important concept that technicians must master to get a thorough understanding of how fluid systems work.

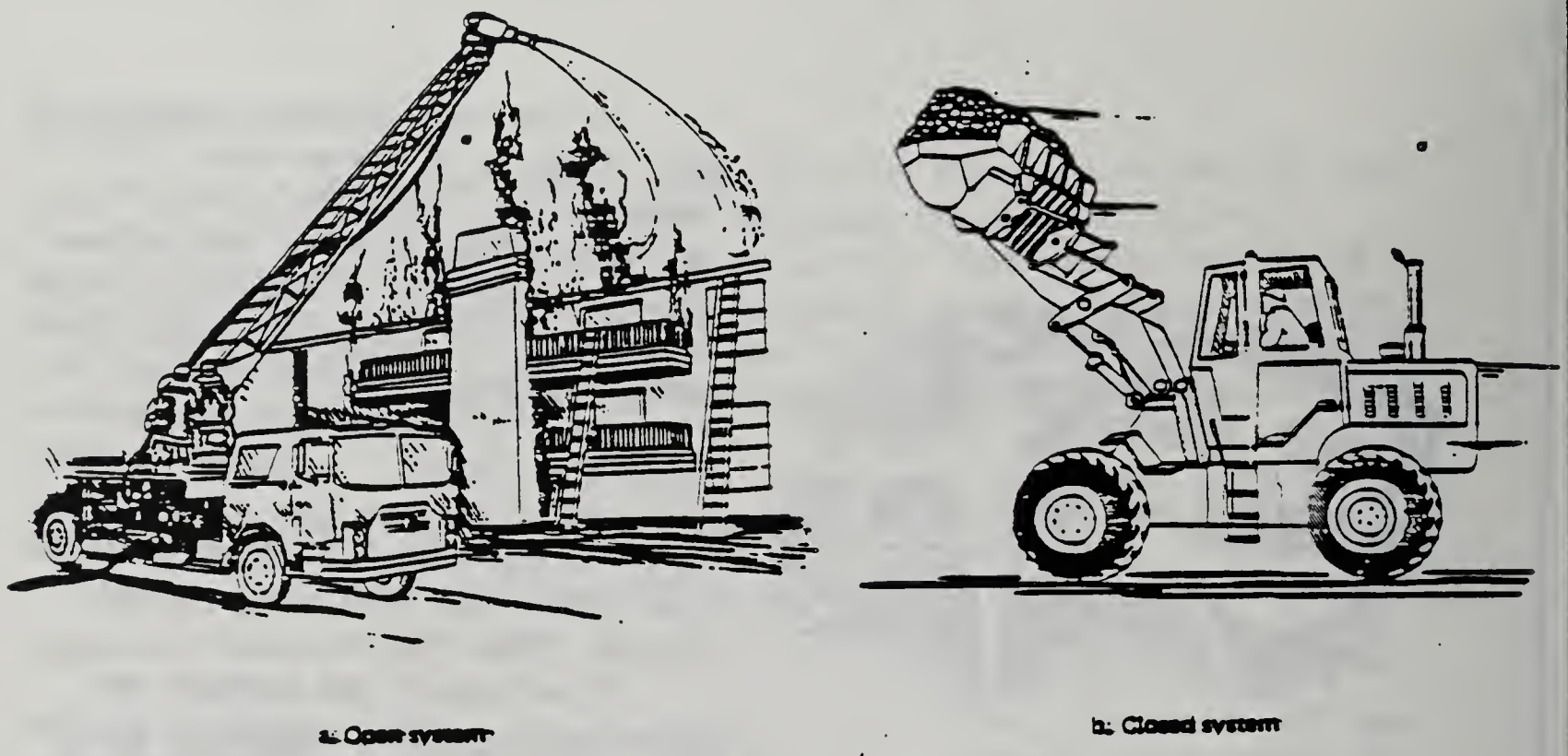


Fig. 3-12 Open and closed systems.

STUDENT EXERCISES

The following exercises review the main ideas and definitions presented in this subunit, "Rate in Fluid Systems." Complete each question as indicated.

1. The rate associated with a fluid system is _____.
   (Circle the correct answer.)
   a. volume flow rate
   b. fluid speed or velocity
   c. mass flow rate
   d. Both a and c.

   The rates associated with the units below may be classified as volume flow rates or mass flow rates. Examine each. Write in the blank provided for each item a "Q_v" for volume flow rate or a "Q_m" for mass flow rate.

2. ___ m^3/sec
3. ___ gram/min
4. ___ liters/sec
5. ___ gal/min
6. ___ kg/min
7. ___ oz/sec

8. In a hydraulic cylinder, _____ (fluid volume, fluid flow rate) determines how fast the piston moves. (Place the correct words in the blank space.)

9. If a leak in a faucet causes a water loss of 120 gallons in two days, what is the volume flow rate per hour (24 hours = 1 day)? (Circle the correct answer and show your work.)
   a. 6.0 gal/hr (Show work here.)
   b. 60 gal/hr
   c. 2.5 gal/hr
   d. 25 gal/hr

10. A car air-conditioner pumps 5 kg of Freon 12 gas through the system in 3 minutes. Find the mass flow rate of the Freon. (Circle the correct answer and show your work.)
   a. 1.7 kg/min (Show work here.)
   b. 12 kg/min
   c. 15 kg/min
   d. None of the above.

11. Where gases are compressed (especially air, which is in common use), storage tanks should be located as close to the point of use as possible because _____. (Complete the explanation in terms of volume flow rate.)

12. The size of pipes delivering fluids over long distances has a direct bearing on making the fluid available where needed. This primarily has to do with _____. (Circle the correct answer.)
   a. volume flow rate control
   b. fluid speed control
   c. Neither a nor b.
   d. Both a and b.

ACTIVITY 1: WRITING DECIMAL NUMBERS IN POWER-OF-10 FORM

DISCUSSION

In Unit 2, "Work," you learned that one coulomb of charge represents 6,250,000,000,000,000,000 electrons. The amount of charge carried by a single electron is 0.00000000000000000001602 coulombs. Very large or very small numbers that require much space and effort to write in decimal notation (as above) are plentiful in technical work. To make large numbers more compact, they are written in a form of notation known as "power-of-10" or "exponential" notation. This method allows the representation of one coulomb of charge to be reduced from 19 numbers to 6.25×10^{18} electrons. The charge carried by an electron goes from 22 numbers to 1.602×10^{-19} coulombs.

To find how this is done, consider the following table.

TABLE I: DECIMAL NUMBER AND POWER-OF-10 EQUIVALENTS

Decimal Number	Power-of-10	Explanation
1,000,000	1×10^6 or 10^6	10 x 10 x 10 x 10 x 10 x 10
100,000	1×10^5 or 10^5	10 x 10 x 10 x 10 x 10
10,000	1×10^4 or 10^4	10 x 10 x 10 x 10
1,000	1×10^3 or 10^3	10 x 10 x 10
100	1×10^2 or 10^2	10 x 10
10	1×10^1 or 10^1	(Usually written without exponent)
1	1×10^0 or 10^0	By definition, any number to zero power equals 1.
0.1	1×10^{-1} or 10^{-1}	$\frac{1}{10}$
0.01	1×10^{-2} or 10^{-2}	$\frac{1}{10 \times 10}$
0.001	1×10^{-3} or 10^{-3}	$\frac{1}{10 \times 10 \times 10}$
0.0001	1×10^{-4} or 10^{-4}	$\frac{1}{10 \times 10 \times 10 \times 10}$
0.00001	1×10^{-5} or 10^{-5}	$\frac{1}{10 \times 10 \times 10 \times 10 \times 10}$
0.000001	1×10^{-6} or 10^{-6}	$\frac{1}{10 \times 10 \times 10 \times 10 \times 10 \times 10}$

Every decimal number can be expressed in power-of-10 notation. The number must be factored into two separate parts, just as 80 can be separated into a product of the factors, 8.0 and 10. In other words, 80 = 8.0 x 10. The first leading factor contains the significant digits of the number, which indicate the accuracy of the number. The second factor, (after the multiplication sign, represented by an "x") is a 10 with an exponent. The exponent is the power-of-10, or how many times 10 is multiplied by itself.

Study Table 2 using Table 1 to verify the answers.

TABLE 2: CONVERSION OF DECIMAL NUMBERS TO POWER-OF-10 (COLUMN B) AND SCIENTIFIC NOTATION (COLUMN C)

Column A		Column B		Column C
375,000	=	375×10^{3}	=	3.75×10^{5}
81,000	=	81×10^{3}	=	8.1×10^{4}
623,000,000	=	623×10^{6}	=	6.23×10^{8}
10	=	100×10^{-1}	=	1.0×10^{1}
0.0715	=	715×10^{-4}	=	7.15×10^{-2}
0.000000133	=	133×10^{-9}	=	1.33×10^{-7}

PRACTICE EXERCISE FOR ACTIVITY 1

Problem: Convert the decimal numbers in Column A to "power-of-10" equivalents in Column B. (Leave Column C blank for now.)

Column A	Column B	Column C
125,000	_____	_____
32,100	_____	_____
1,521	_____	_____
1,921,000	_____	_____
0.0000192	_____	_____
0.11050	_____	_____
0.567	_____	_____
22	_____	_____

All the following power-of-10 notations express the same number--81,000.

$$81{,}000 = 8.1 \times 10^{4}$$
$$= 81 \times 10^{3}$$
$$= 810 \times 10^{2}$$
$$= 8100 \times 10^{1}$$
$$= 0.81 \times 10^{5}$$

ACTIVITY 2: WRITING POWER-OF-10 NUMBERS IN DECIMAL FORM

DISCUSSION

Since power-of-10 numbers express where to place the decimal (to the right or left) when rewriting to decimal form, the decimal process is just the reverse of Activity 1.

From Table 1, 10^4 means that the decimal place is placed four places to the right of 1. So, $1 \times 10^4 = 10000. = 10{,}000$. If the number is 10^{-4}, then the decimal is placed four places to the left of 1. So, $1 \times 10^{-4} = (0.0001)$.

PRACTICE EXERCISE FOR ACTIVITY 2

Problem: Convert the power-of-10 numbers in Column A to decimal numbers. Place the answers in Column B. (Leave Column C blank for now.)

Column A	Column B	Column C
326×10^3	_____	_____
41.98×10^4	_____	_____
2.12×10^{-4}	_____	_____
6.1×10^5	_____	_____
3.06×10^2	_____	_____
1.2×10^{-3}	_____	_____
0.81×10^5	_____	_____

Remember that power-of-10 numbers can be written in more than one way.

ACTIVITY 3: WRITING DECIMAL NUMBERS AND POWER-OF-10 NUMBERS IN SCIENTIFIC NOTATION

DISCUSSION

When converting decimal numbers to power-of-10 numbers, or vice versa, do not round off or drop significant digits. The conversion used should not affect accuracy. While not a fixed rule, the first factor is represented as a number between 1 and 10. This type of expression is a special exponential notation known as **scientific notation.** Scientific notation is simply a number written as a number between 1 and 10, multiplied by the number 10 that is raised to some power. See Figure 1.

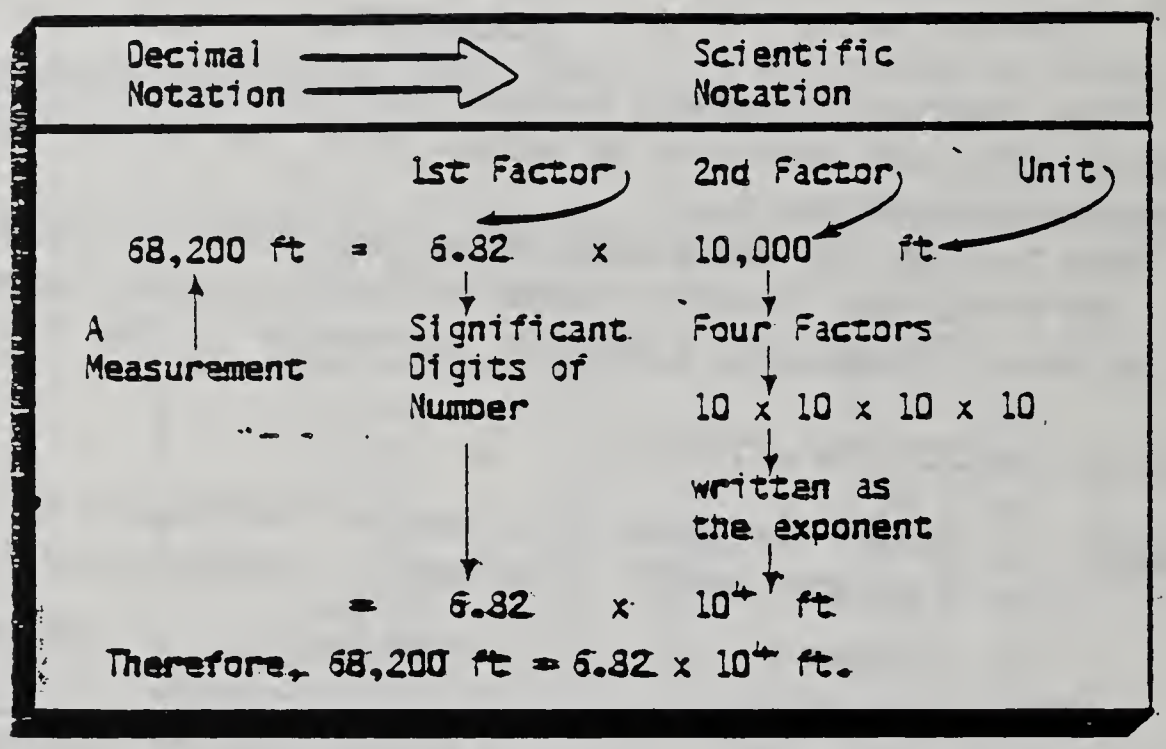


Fig. 1 Expressing a number in scientific notation.

The following numbers in Column C from Table 2 are written in scientific notation as shown below:

3.75×10^5	1.0×10^1
8.1×10^4	7.15×10^{-2}
6.23×10^8	1.33×10^{-7}

PRACTICE EXERCISES FOR ACTIVITY 3

Problem 1: Convert the decimal numbers in Exercise 1, Column A, to scientific notation. Place answers in Column C of Exercise 1.

Problem 2: Convert the power-of-10 numbers in Exercise 2, Column A, to scientific notation. Place answers in Column C, Exercise 2.

In a future Math Skills Lab, you'll learn to add, subtract, multiply and divide using power-of-10 numbers. You will also learn how to use a calculator to perform these operations.

ACTIVITY 4. CONDUCTING MATHEMATICAL OPERATIONS WITH NUMBERS EXPRESSED IN POWER-OF-10 FORM

DISCUSSION

In a previous lab exercise, you were required to state decimal numbers in exponential, or power-of-10, form. The exponent of 10 determined placement of the decimal when converting back to decimal numbers.

This exercise will explain how to conduct math operations on numbers with power-of-10 form. Table 1 from your previous lab can serve as a guide to check your work.

The following rules must be observed to obtain correct answers when adding or subtracting power-of-10 numbers.

Rule 1: Any number to the zero power (exponent) is equal to 1.

Examples: $10^0 = 1$; $2^0 = 1$; $5^0 = 1$.

Rule 2: Any number to the first power is equal to that number.

Examples: $10^1 = 10$; $2^1 = 2$; $5^1 = 5$.

Rule 3: Before numbers are added or subtracted, the exponents of 10 must be the same. The first factor need not be between 1 and 10.

Example 1: Add 2.610×10^3 to 6.2000×10^4

$2.610 \times 10^3 = 2.610 \times 10^3$ (left as is)

$6.2000 \times 10^4 = 62.000 \times 10^3$ (changed to a power-of-10^3)

Now add:

$$\begin{array}{r} 2.610 \times 10^3 \\ (+)\,62.000 \times 10^3 \\ \hline 64.61 \times 10^3 \end{array}$$

or 6.461×10^4

Example 2: Subtract 7.81×10^{-7} from 3.930×10^{-6}

$3.930 \times 10^{-6} = 3.930 \times 10^{-6}$ (left as is)

$7.81 \times 10^{-7} = 0.781 \times 10^{-6}$ (changed to a power-of-10^{-6})

Now subtract:

$$\begin{array}{r} 3.930 \times 10^{-6} \\ (-)\,0.781 \times 10^{-6} \\ \hline 3.149 \times 10^{-6} \end{array}$$

REMEMBER: The number 10 raised to different exponential powers cannot be added or subtracted any more than apples and oranges can.

PRACTICE EXERCISES FOR ACTIVITY 4

Problem 1: ADD the following numbers in exponential form.

$$\begin{array}{rl} & 3.172 \times 10^{4} = \\ + & 6.210 \times 10^{3} = \\ \hline \end{array}$$

$$\begin{array}{rl} & 52.73 \times 10^{3} = \\ + & 21.326 \times 10^{4} = \\ \hline \end{array}$$

$$\begin{array}{rl} & 1.235 \times 10^{-11} = \\ + & 21.6 \times 10^{-13} = \\ \hline \end{array}$$

SUBTRACT the following numbers in exponential form.

$$\begin{array}{rl} & 4.631 \times 10^{-7} = \\ - & 6.82 \times 10^{-8} = \\ \hline \end{array}$$

$$\begin{array}{rl} & 18.21 \times 10^{4} = \\ - & 122.1 \times 10^{3} = \\ \hline \end{array}$$

The following rule applies to multiplying power-of-10 numbers.

Rule 4: The first factors (decimal part) of each number are multiplied. But the exponents of 10 are added algebraically. The result is a product of the first factors times (x) a power of 10.

Example 1: $(3.2 \times 10^{4}) \times (1.5 \times 10^{2})$
$= (3.2)(1.5) \times 10^{4+2}$
$= 4.8 \times 10^{6}$

Example 2: $(3.2 \times 10^{-3}) \times (1.5 \times 10^{2})$
$= (3.2)(1.5) \times 10^{-3+2}$
$= 4.8 \times 10^{-1}$

Problem 2: MULTIPLY the following numbers in exponential form.

$(5.5 \times 10^3)(2 \times 10^4)$

= _____

= _____

$(2.2 \times 10^{-3})(2.5 \times 10^4)$

= _____

= _____

$(9 \times 10^5)(4 \times 10^{-2})$

= _____

= _____

The following rules apply to dividing power-of-10 numbers.

Rule 5: Whenever 10 has a power with a negative sign, such as 10^{-1} or 10^{-2}, it is equal to the number, one, divided by 10 with the same power and a positive sign. For example:

$$10^{-1} = \frac{1}{10^1} = \frac{1}{10}$$

$$10^{-2} = \frac{1}{10^2} = \frac{1}{10 \times 10} = \frac{1}{100}$$

$$10^{-3} = \frac{1}{10^3} = \frac{1}{10 \times 10 \times 10} = \frac{1}{1000}$$

Rule 6: In division, the first factors of each number are divided. But the exponents of 10 are subtracted algebraically. The result is the quotient of the first factors times (x) a power of 10.

Example 1: $$\frac{8.4 \times 10^9}{2.1 \times 10^4} = \frac{8.4}{2.1} \times 10^{9-4}$$
$$= 4.0 \times 10^5$$

Example 2: $\frac{8.4 \times 10^{7}}{2.1 \times 10^{-3}} = \frac{8.4}{2.1} \times 10^{7-(-3)}$ (NOTE: A "minus times a minus" is equal to a "plus," thus -(-3) is equal to +3.)

$= 4.0 \times 10^{10}$

Problem 3: DIVIDE the following numbers in exponential form.

$\frac{3.6 \times 10^{5}}{1.2 \times 10^{3}} =$ ____ x ____

$\frac{9.6 \times 10^{8}}{8 \times 10^{-4}} =$ ____ x ____

$\frac{10.5 \times 10^{-3}}{5 \times 10^{-1}} =$ ____ x ____

ACTIVITY 2: USING POWERS-OF-10 NUMBERS TO SOLVE PRINCIPLES OF TECHNOLOGY PROBLEMS

DISCUSSION

This activity will combine the skills learned in calculating unknowns when using power-of-10 numbers. These skills are best learned by practice.

Problem 1:

Given: An air-conditioner duct has a pressure difference of 126.5×10^{-4} lb/in^2 when the fan moves 50,000 in^3 of air.

Find: Work done by the fan.

Solution: WORK = PRESSURE DIFFERENCE x VOLUME MOVED.

$W = \Delta P \times V$

$W = (126.5 \times 10^{-4} \frac{lb}{in^2})(50{,}000\ in^3)$

$W = (126.5 \times 10^{-4})(5 \times 10^{4}) \frac{lb}{in^2} \times in^3$

$W = (126.5)(5) \times 10^{-4+4+4}$ in•lb

$W = 632.5 \times 10^{0} = 632.5$ in•lb.

Problem 2:

Given: A bullet leaves the barrel of a rifle with a speed of 0.125×10^3 m/sec.

Find: Distance traveled in three seconds.

Solution: $\text{SPEED} = \dfrac{\text{DISTANCE TRAVELED}}{\text{ELAPSED TIME}}$, or $v = \dfrac{\ell}{t}$.

$v = \dfrac{\ell}{t}$ (To find distance, isolate ℓ by multiplying both sides of equation by t.)

$tv = \dfrac{t\ell}{t}$ (Cancel t's.)

This leaves $\ell = vt$.

$\ell = (0.125 \times 10^3 \frac{m}{sec})(3\ sec)$ (Cancel seconds.)

$\ell = (0.125\ m)(3) \times 10^3$

$\ell = 0.375 \times 10^3\ m$

$\ell = 375\ m$.

PRACTICE EXERCISE FOR ACTIVITY 5

Problem: Given: Several forces were recorded by sensors in a test on an aircraft wing at one point. These forces, all acting in the same direction, were as follows:

$f_1 = +1.22 \times 10^4$ oz

$f_2 = +3.1 \times 10^3$ oz

$f_3 = +1.08 \times 10^5$ oz

Find: The total force (F) at the point mentioned.

Solution: $F = f_1 + f_2 + f_3$

$F =$ _____.

INTERMEDIATE OBJECTIVE #6

Describe the similarities of related technology circuits and components.

LEARNING STEPS (Activities)

1. Read Information Sheet cited in Resource #1 to recognize technology similarities.

2. Complete the written criteria evaluation cited in Resource #2 to prove mastery of this Intermediate Objective.

3. Upon satisfactory completion step #2 above, proceed to the next learning guide.

RESOURCES

1. Information Sheet #6 page 69 - 75 entitled "Unified Technology Concepts".

2. See your instructor for the criteria evaluation for this Intermediate Objective.

3. See your instructor for learning guide 212.

INFORMATION SHEET #6

UNIFIED TECHNOLOGY CONCEPTS

OBJECTIVE: To recognize the similairity of related technology circuits and components

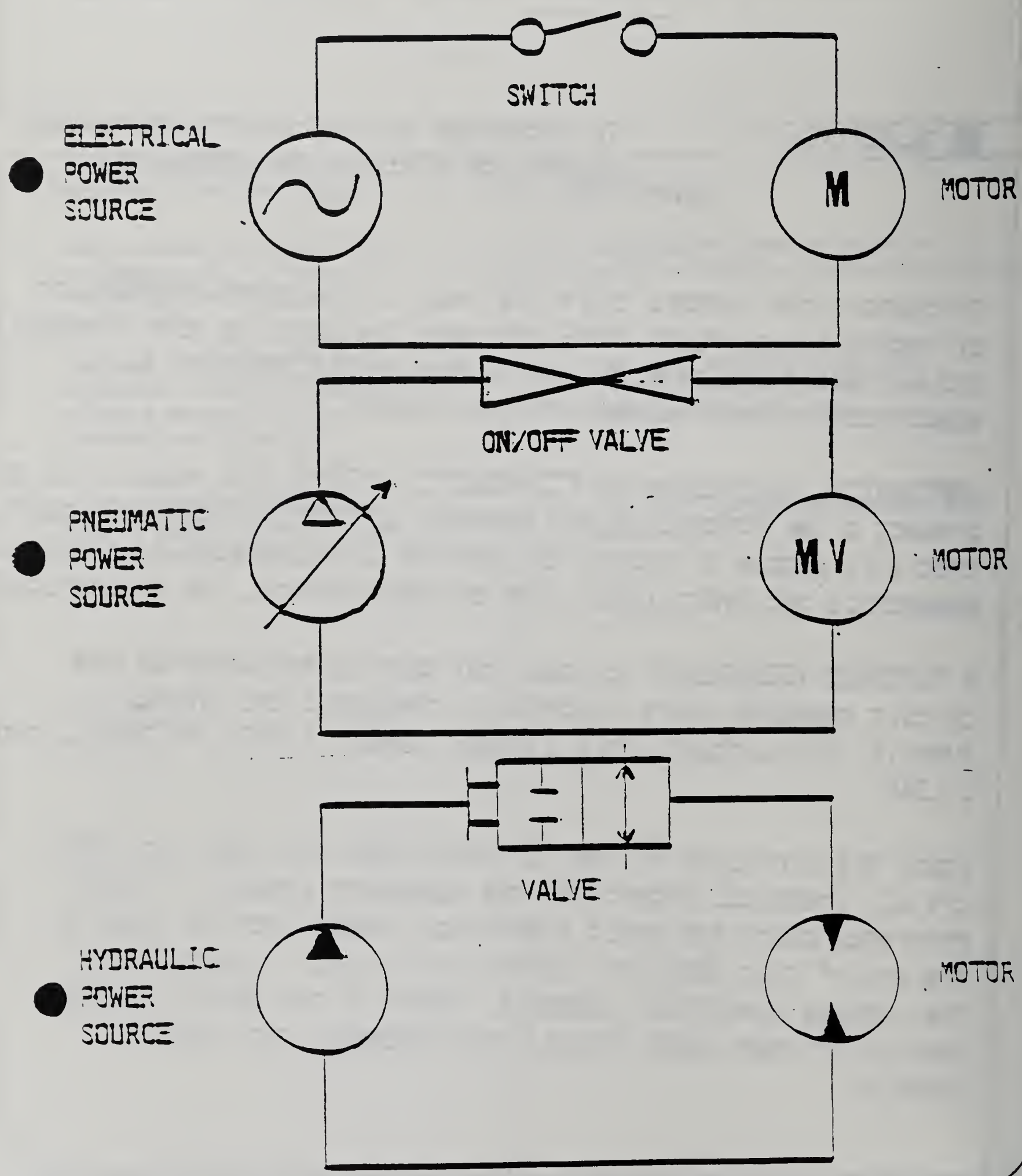
Througnout the decades there has been a consistent segregation of technologies. FLUID POWER has been presented as both Pneumatic and Hydraulic and never being related to ELECTRICITY! As electricity is not related to fluid power.

AMPTRONICS, a divtsion of TTI ROBOTIC SYSTEMS INC. would like to present a new concept to the student, a UNIFIED TECHNOLOGY course that will enable a student to identify circuits both in electricity, pneumatics and hydraulics, with the main emphasis on pneumatics.

A "UNIFIED TECHNOLOGY" circuit can best be explained as one circuit repeated using electrical, pneumatic and hydraulic symbols. All circuits have a POWER SOURCE, A PATH OF TRAVEL and a LOAD.

Study the ciricuits on the following page and note that they are all identical except for the component symbols! A quick reference chart for basic electrical symbols can be found at the end of this activity inorder to aid you in recognizing the various electrical sysmbols. Refer to the GRAFIC SYMBOLS section of your other manuals for pneumatic and hydraulic symbols.

UNIFIED TECHNOLOGY CONCEPTS



INFORMATION SHEET

Each source of power may take many forms, such as AC & DC electrical power, compressed air or a hydraulic system. Switches, valves and loading devices will also take many different forms, however, all components regardless of the technology, will be dictated by the application needs!

When studying an application problem, the "UNIFIED TECHNOLOGY CONCEPT" can be applied. After all surrounding conditions have been determined, one of the three concepts, (electrical, pneumatic, or hydraulic) can be used.

As you proceed through the following activities, take the time to draw each circuit using the "UNIFIED TECHNOLOGY CONCEPT". As your abilities increase, you will find that each circuit and application may have a more suitable alternative depending upon the surrounding environment of the application.

Using your present Electrical course manual or the QUICK REFERENCE GUIDE supplied in this manual and the "ROBOTIC APPLICATIONS FOR PNEUMATICS & HYDRAULICS", layout and draw the following circuit for all three technologies. Use any switching or load devices that you may choose.

Additional work sheets have been provided so you may try your abilities in the "UNIFIED TECHNOLOGY CONCEPT" of some of the activities in this manual.

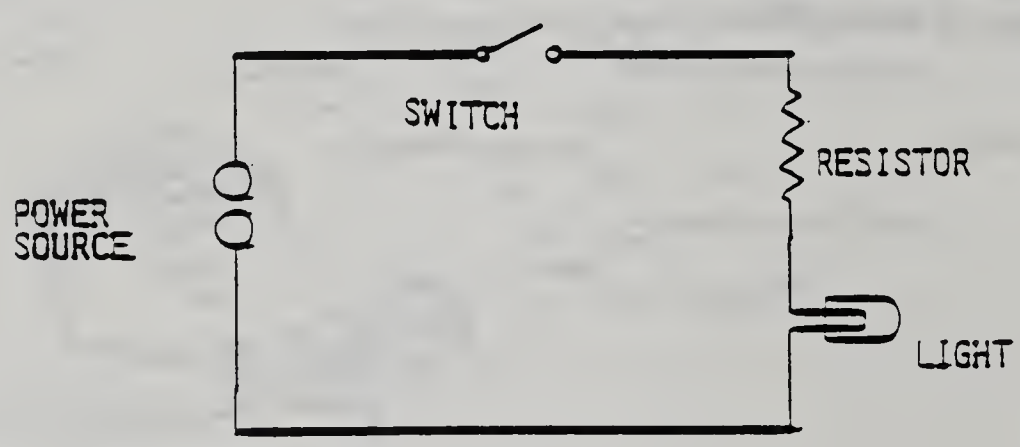
UNIFIED TECHNOLOGY CONCEPTS

WORKSHEET

- PNEUMATIC CIRCUIT

- HYDRAULIC CIRCUIT

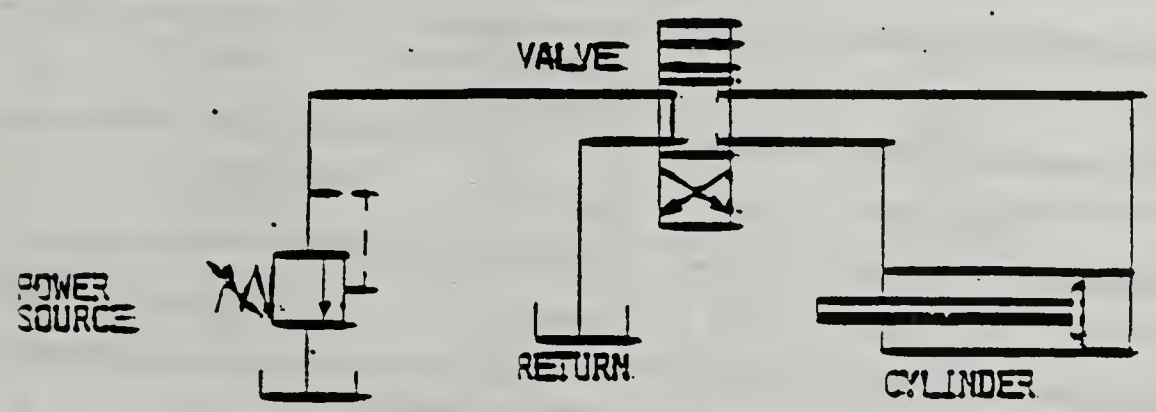
- ELECTRICAL CIRCUIT



WORKSHEET

● PNEUMATIC CIRCUIT

● HYDRAULIC CIRCUIT



● ELECTRICAL CIRCUIT

ELECTRICAL QUICK REFERENCE CHART

COMPONENT DESCRIPTION	GRAPHIC SYMBOL	LETTER SYMBOL
Connection, ground		gnd
Diode, semiconductor		CR
Field Effect (Junction) Transistor, N Channel		Q
P Channel		Q
Fuse		F
Galvanometer	G	G
Generator	GEN	GEN
Lamp		LP
Meter (insert letter indicating function V = voltmeter A = ammeter, etc.)		M
Milliammeter	mA	mA
Millivoltmeter	mV	mV
Motor, ac	MOT	MOT
Motor, dc	MOT	MOT
Neon Lamp		LP
Ohmmeter	OHM	OHM

COMPONENT DESCRIPTION	GRAPHIC SYMBOL	LETTER SYMBOL
Potentiometer		R
Resistor, fixed		R
tapped		R
Relay, normally closed (NC)		K
Rheostat		R
Silicon Controlled Rectifier (SCR)		Q
Solar Cell		SC
Speaker		SPKR
Switch, Single-Pole-Single Throw (SPST)		S
Single-Pole-Double-Throw (SPDT)		S
Double-Pole-Single-Throw (DPST)		S
Double-Pole-Double-Throw (DPDT)		S
Pushbutton, normally closed (PBNC)		S
Pushbutton, normally open (PBNO)		S
Rotary		S

ELECTRICAL QUICK REFERENCE CHART

COMPONENT DESCRIPTION	GRAPHIC SYMBOL	LETTER SYMBOL
Terminal		
Thermistor		RT
Thermocouple		TC
Transformer, Air Core		T
Iron Core		T
Autotransformer		T
Transistor NPN		Q
PNP		Q
Vacuum Tube diode		V
triode		V
pentode		V
Voltmeter	V	V
Wattmeter	W	W
Zener diode		CR

COMPONENT DESCRIPTION	GRAPHIC SYMBOL	LETTER SYMBOL
AC generator		GEN
Ammeter	A	A
Battery		B
Capacitor, fixed		C
electrolytic (fixed)		C
variable		C
Cell		B
Conductor		
cross, no connection		
connection		
Coil, air core		L
Coil, adjustable		L
Coil, fixed tap		L
Coil, iron core (choke)		L
Connection, chassis		

PROGRAM INDUSTRIAL ELECTRICAL MAINTENANCE

CRITERION EXAM

TASK = 211 DESCRIBE UNIFIED TECHNOLOGY CONCEPTS

DIRECTIONS:

THE PURPOSE OF THIS EXAM IS TO DETERMINE WHETHER OR NOT YOU HAVE UNDERSTOOD THE INFORMATION ON UNIFIED TECHNOLOGY CONCEPTS.

Each of the questions or incomplete statements below is followed by several words, phrases, or a series of numbers. Choose the one which best answers the question or completes the statement correctly. Place the letter associated with that choice (A,B,C or D) in the numbered blank space on your ANSWER SHEET. DO NOT WRITE ON THIS TEST!!! To master this exam you must answer 10 out of 10 items correctly, 100 %.

EVALUATION SHEET

UNIFIED TECHNOLOGY CONCEPTS

1. Charles Law states:

2. When a moving piston does work in a hydraulic cylinder, the pressure exerted by the piston is multiplied by _____.

   A. area of the piston face
   B. fluid volume displaced
   C. weight density of the fluid

3. Pneumatic and electric systems use similar mathematic expressions for doing work. Write the expressions for each below.

   Pneumatic work formula equals _____

   Electric work formula equals _____

4. Open fluid systems do not make provision for _____.

5. The term "mass flow rate" is symbolized using Qm. Complete the expression for Qm:

6. The term "Volume flow rate" refers to _____divided by elapsed time.

7. Write .00000148 in scientific notation. _____

8. Write the expression 1.23 X 10E-4 in decimal notation. _____

9. Add these two fractions: 12/45 plus 6/135 = ? .

10. All circuits have a _____, a _____ and a load.

LAKE
COUNTY
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COMPETENCY-BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

STUDENT LEARNING GUIDE

Produced By M. H. WHITMER Date 4/85

TASK: IDENTIFY FLUID SYSTEM COMPONENTS

PURPOSE: You must understand fluid system components as they apply to robotics and automated manufacturing. The intermediate objectives under this task presents the fluid system components to help you achieve the needed understanding. The modern electrical maintenance person knows how fluid systems work so that troubles can be identified and repairs effected rapidly.

INDUSTRIAL ELECTRICAL MAINTENANCE

Program	Task	Est.Time	Prereq.
17.1002	212	2 hrs	211

edk

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME _____ SOCIAL SECURITY NUMBER _____

LENGTH OF CONTRACT (NORMAL TIME IN HOURS) _____

2. TERMINAL PERFORMANCE OBJECTIVE

Given a written evaluation and a performance checklist, you will identify fluid system components on the written evaluation and select the correct components from those supplied with the trainer. You must score 100% on the written test and 100% on the performance checklist for this objective.

2a. INTERMEDIATE OBJECTIVE(s)

1. Identify air and hydraulic components.
2. Identify common electrical sensors.

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____. I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

Student's Signature _____

Instructor's Signature (verifies competency) _____

INTERMEDIATE OBJECTIVE

Identify air and hydraulic components.

LEARNING STEPS (Activities)

1. Read the information sheets cited in Resource #1 to learn the fluid components.

2. Complete the self help exam cited in Resource #2, to assure mastery of the subject.

3. Proceed to the next Intermediate Objective.

RESOURCES

1. Information Sheet #1, starts on page 4 and is entitled "Popular Fluid Components".

2. Self-help Exam #1 begins on page 13 and is entitled "SelfHelp on Fluid and Electrical Components."

3. The next Intermediate Objective begins on page 15.

INFORMATION SHEET #1

"FLUID COMPONENTS"

In most air and hydraulic fluid power circuits, valving is used to control (a), direction of fluid flow, (b), rate of fluid flow, and (c), maximum level of pressure. Control valves for these three functions can be purchased with solenoid actuators. It is then possible to control these functions remotely or to tie the valve action into an overall electrical circuit for atuomatic or semi-automatic action, or remote control.

Directional valves are the ones most often operated by solenoids, although to a limited extent 2-way solenoid controlled valves are used for deceleration control, step level pressure control, pump unloading, and flow control (usually on hydraulics).

Air valves and hydraulic valves both operate in the same way and are electrically controlled in thesame way but overall circuitry for the two fluid mediums is different. For example, most air circuits use 2-position solenoid valves and hydrolic circuits use 3-positions valves. Pump unloading must air circuits use 2-position solenoid valves and hydraulic circuits use 3-positions valves. Pump unloading must be considered when designing for hydraulics but is not a requirement when designing for air. After careful consideration of the best way to present both air and hydraulic circuitry, we have decided to present each topic, such as cylinder reciprocation, cylinder sequencing, safety circuits, ect., and to give examples first of air circuitry then of hydraulic circuitry before proceeding to the next topic.

We are briefly describing some of the electrical components available for control of fluid power for the benefit of those who may have some familiarity with fluid power but not with electrical control. The electrical components described here represent only a small proportion of the large variety available to the designer. Our listings are intentionally limited to the most widely used types; those which are most often used for control of fluid power, and we have tried to select for illustration those components available from several manufacturers rather than those of a proprietary nature available only from one source. Some manufacturers rather than those of a proprietary nature available only from one source. Some manufacturers may offer components which serve the purpose equally well but which have a somewhat different appearance. To completely describe all similar equipemnt would require a large book devoted entirely to this subject.

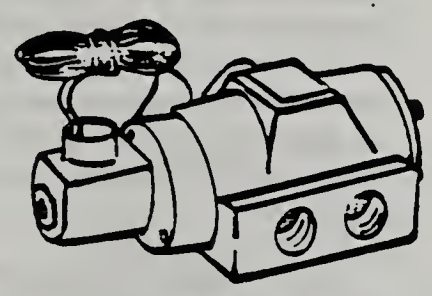
A. FLUID COMPONENTS AVAILABLE—AIR AND HYDRAULIC

1. Directional Control Valves — 4-Way

A directional valve is defined as one which controls the direction of flow of a fluid, either liquid or air, in a fluid power circuit. Flow direction of the fluid determines the direction of travel of a cylinder, forward or reverse, and the direction of rotation, clockwise or counter-clockwise, of a fluid motor. While most circuits require only one directional valve for each output actuator (or group of actuators), there are some circuits for special purposes which may require several in order to obtain the range of control needed.

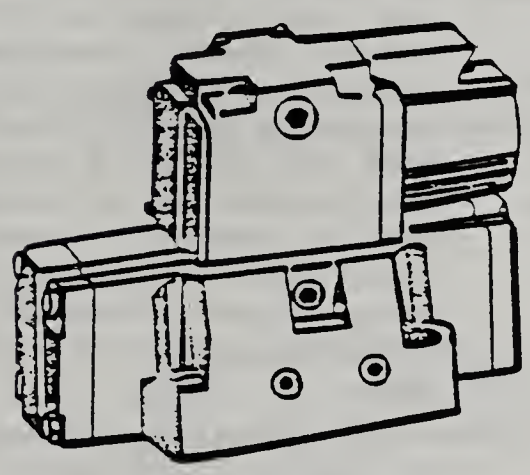
Four-way directional valves are usually considered as standard for operation of a double-acting cylinder. They are built in a wide variety of shapes and sizes, and may vary in appearance from those shown in our illustrations, but the solenoid valves shown are sketched from popular brands in common use.

Electrically controlled directional valves respond to an electrical signal for shifting their spools or poppets, to provide different flow paths through the internal porting to their outlet ports. They are built as 2-way, 3-way, 4-way, and 5-way types. The student is referred to "Industrial Fluid Power — Volume 1"*. for further description of these types. In the majority of applications, 4-way valves are used for control of double-acting cylinders and reversible fluid motors.

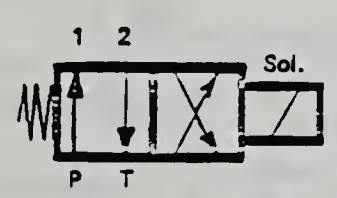


A. Typical Air Valve

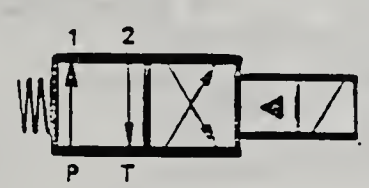
Single Solenoid 4-Way Valves. Figure 1-1. This type is identified by its having only one solenoid coil. When this coil is energized, the valve spool is shifted against spring force to its opposite side position and held in this position as long as the solenoid coil remains energized. The single solenoid valve is said to require a "maintained" electrical signal to keep its spool shifted. There are only two valving positions; no center neutral spool positioning is possible.



B. Typical Hydraulic Valve.



C. Graphic Symbol for Direct-Acting Single Solenoid 4-Way Valve.



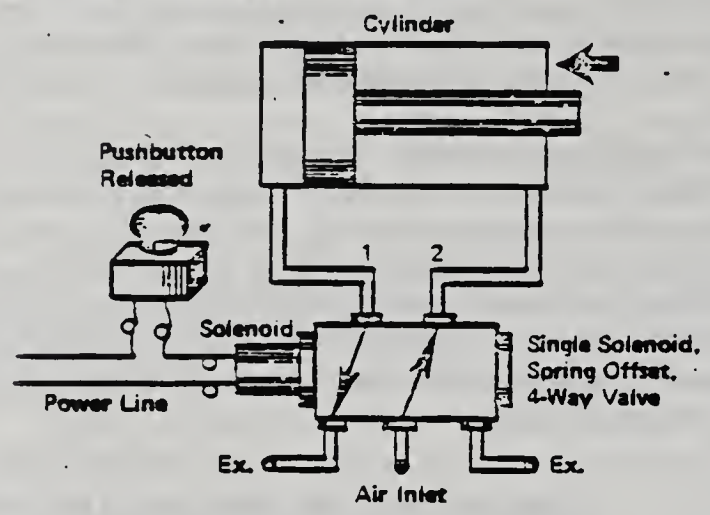
D. Graphic Symbol for Pilot-Operated Single Solenoid 4-Way Valve.

(P is pressure port; T is tank return on hydraulic valve, exhaust on air valve; 1 and 2 are cylinder ports).

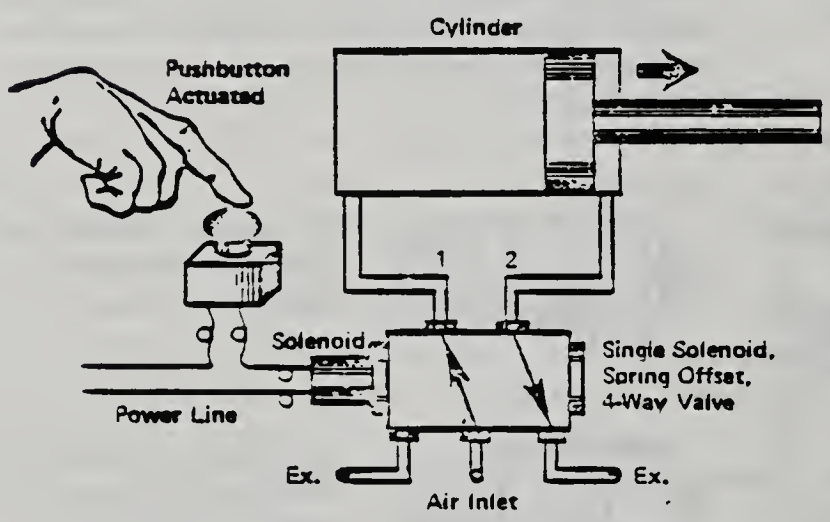
FIGURE 1-1. Single Solenoid 4-Way Valves.

**Textbook available from Womack Educational Publications. See title page for address of publisher.*

Action of a Single Solenoid Valve. Figure 1-2. The basic action of a single solenoid valve in controlling a standard double acting cylinder is shown in the two illustrations below. A pushbutton is wired in series with the valve coil to the 115-volt power line. During the time the button is not actuated, Part A figure, the valve spool is held in its normal side position by an internal spring, and fluid pressure is directed to the rod end of the cylinder, which causes it to retract, and holds it against the rear end cap with full pressure. Note: If fluid lines 1 and 2 to the cylinder were to be reversed, the starting position of the cylinder would be at full extension.



A. Cylinder retracts when normally open electric pushbutton is released.



B. Cylinder extends when normally open electric pushbutton is pressed.

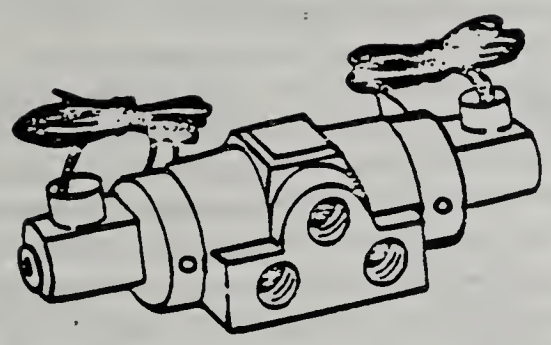
FIGURE 1-2. Pushbutton Control of an Air Cylinder With a 4-Way Single Solenoid Valve.

When the button is pressed, Part B of the figure, the solenoid shifts the valve spool to its opposite side position, and fluid pressure is directed to the blind end of the cylinder causing the piston rod to extend, and eventually holding it against its forward end cap under full pressure. However, if at any point in the piston stroke the button is released, the valve spool will be returned to its normal position and the cylinder will immediately start its retraction stroke even though the forward stroke has not been completed.

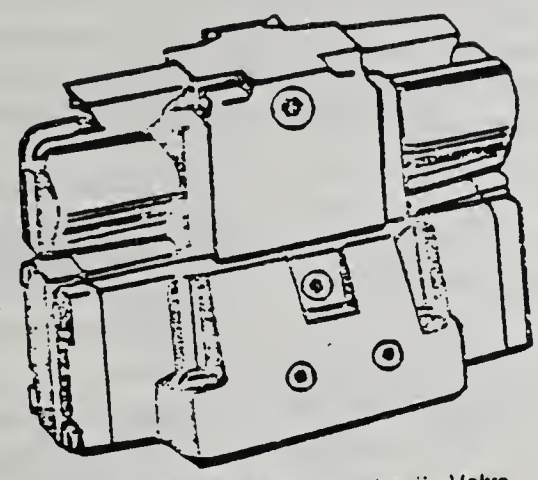
Since there can be no neutral position on a single solenoid valve, there is no electrical means by which the cylinder piston can be stopped in between its extremes of travel.

Double Solenoid 4-Way Valves. Figure 1-3. A double solenoid valve can be identified by its having two solenoid coils, usually on opposite ends of the valve body. However, a visual inspection may not reveal whether the valve is a 2-position model, or a 3-position model with center neutral position. This information can be obtained either by comparing its nameplate model number with the manufacturers catalog, or by physical inspection, removing the spool to look for centering springs.

Valves with no centering springs on the spool are called "2-position, no-spring" models. Those with centering springs as "3-position, spring centered". However, some large valves may have pressure centered spools.

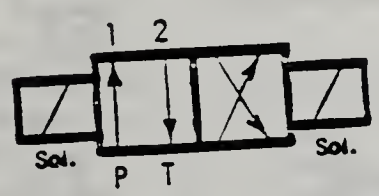


Typical Double Solenoid Air Valve.

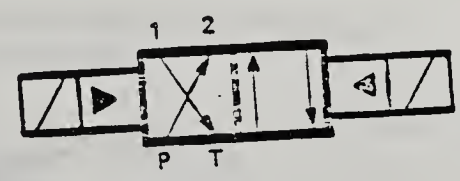


Typical Double Solenoid Hydraulic Valve.

FIGURE 1-3. Examples of Double Solenoid 4-Way Valves.

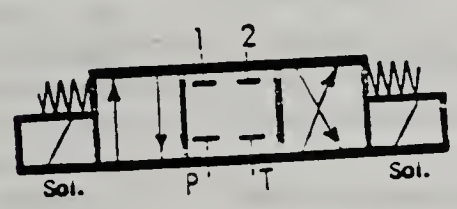


Direct-Acting Double Solenoid Valve.

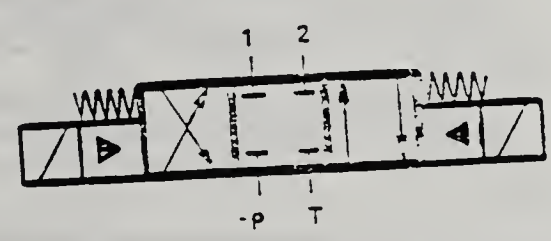


Pilot-Operated Double Solenoic Valve.

FIGURE 1-4. Graphic Symbols for 2-Position Double Solenoid 4-Way Valves, Air or Hydraulic. (P is pressure port; T is tank return or air exhaust; 1 and 2 are the Two Cylinder Ports).



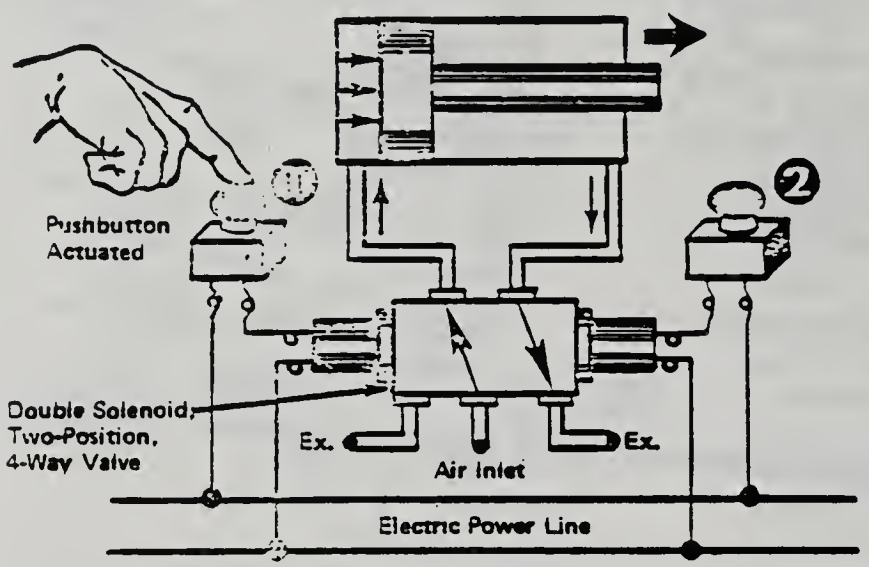
Direct-Acting Spring Centered Double Solenoid Valve.



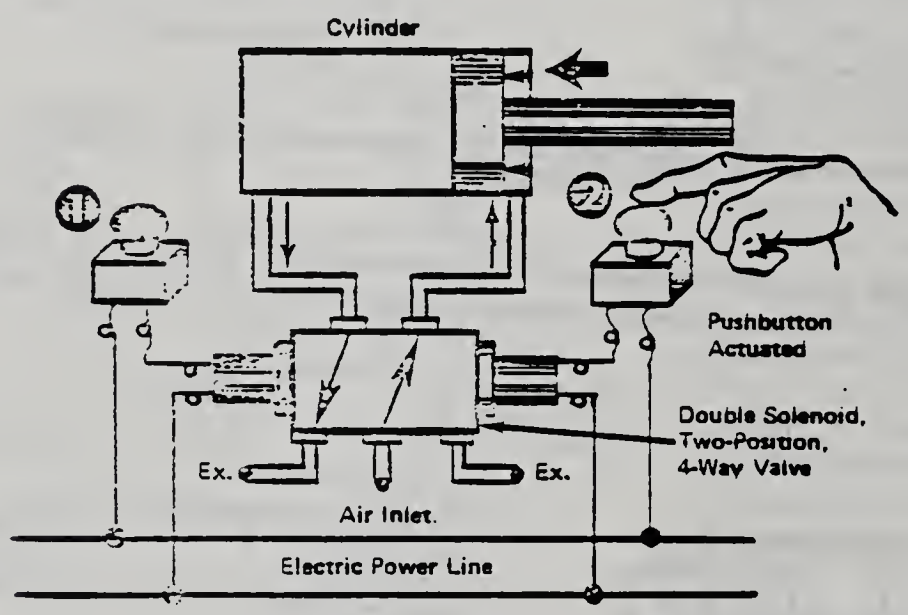
Pilot-Operated Spring Centered Double Solenoid Valve.

FIGURE 1-5. Graphic Symbols for 3-Position Double Solenoid 4-Way Valves. (Air or Hydraulic)

Action of Double Solenoid Valve. Figure 1-6. The illustrations on this page show the action of a 2-POSITION double solenoid valve in operating a standard cylinder, air or oil. A 2-position valve is said to require a "momentary" electrical signal for its operation. Once the valve spool has been shifted by solenoid action, it will remain in that position, even though the solenoid is de-energized, until the opposite solenoid is energized. Most valves will shift reliably on a signal duration as short as 1/10th second.



A. Cylinder extends when electric pushbutton on the left is pressed.*



B. Cylinder retracts when electric pushbutton on the right is pressed.*

Part A, Figure 1-6. When the left pushbutton, 1, is momentarily pressed, the valve spool is shifted to its opposite position, directing inlet air to the back side of the cylinder piston, causing it to move forward. It will continue to travel until it stalls against the work or against its front end cap.

Part B, Figure 1-6. Pressing the pushbutton on the right shifts the valve spool back to its original position, which directs air flow into the rod end of the cylinder. The piston retracts until reaching stall against its rear end cap.

Reversal can be made to take place at any point in the piston stroke while the piston is traveling. But since the valve has only two working positions, there is no electrical means by which the piston can be stopped at any intermediate point in its travel.

Design Note: All spool-type 4-way valves should preferably be mounted with spool in a horizontal plane to avoid the possibility of self-shift due to excess flow or vibration.

FIGURE 1-6. Pushbutton Control of a Cylinder With 2-Position Double Solenoid Valve.

**Some brands of double solenoid valves may have reverse action: Energizing left solenoid may cause cylinder to retract.*

Action of 3-Position Double Solenoid Valve. Please refer to Figure 1-6. That illustration may also be used to describe the action of a 3-POSITION valve in controlling a standard double-acting cylinder.

Electrical connections are the same whether for a 2-position or a 3-position valve, but the internal action is different on the two types, and the overall electrical control circuit must be designed differently. The 3-position type has a spring centered neutral position of its spool, and this center spool position is used to stop a cylinder at any intermediate point between the two extremes of its piston travel. Because of centering springs on the valve spool it is necessary to hold current on one solenoid or the other to keep the valve spool in one of its side positions for keeping the cylinder in motion. Therefore, a 3-position valve is said to require a "maintained" electrical signal for its operation; anytime both solenoids are de-energized the valve spool will become centered and the cylinder will stop.

Note: Some brands of double solenoid valves will have one coil burn out if both coils are energized at the same time and if this condition is maintained very long or repeated very often. This includes all those valves where the two solenoids are connected to opposite ends of the same spool. When using valves of this type the electrical circuit should be arranged to make it impossible to have current on both solenoids at the same time. Interlocking circuits are shown in Chapter 8.

2. Directional Control Valves — 3-Way, Single Solenoid.

Used principally to control single-acting air cylinders; sometimes, but not often, used to control hydraulic cylinders on very special applications some of which are described in "Volume 2 — Industrial Fluid Power". Sometimes used for vacuum control.

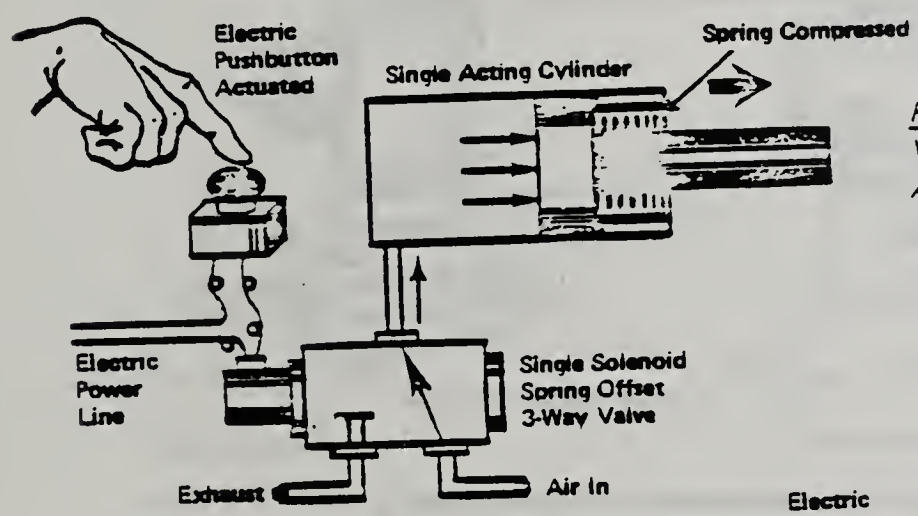
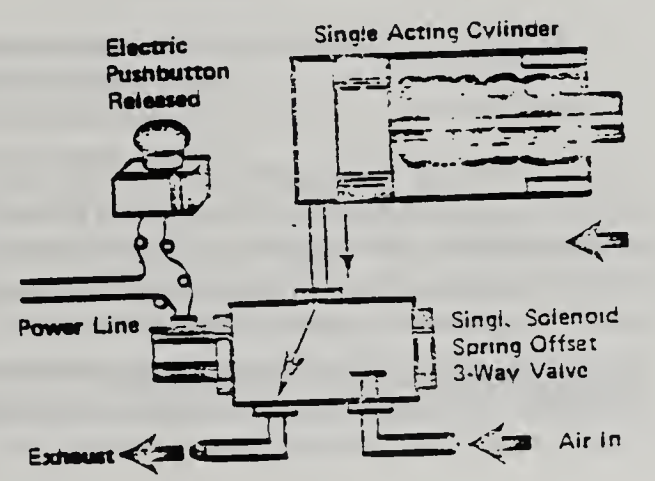


FIGURE 1-7. Action of a 3-Way Valve in Controlling a Single-Acting, Spring Return Cylinder.

Above: When pushbutton is pressed, valve spool shifts, directing fluid pressure behind the cylinder piston, causing it to move forward.



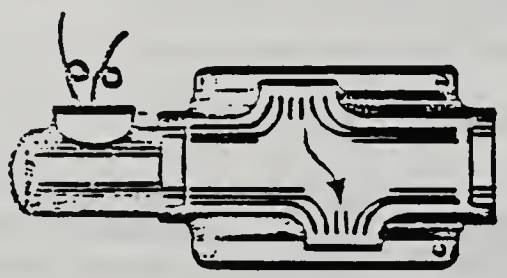
Right: When button is released, valve spool returns to original position, venting cylinder piston to exhaust, allowing internal spring to return cylinder piston to normal position.

Spool-type 3-way valves are usually similar in appearance and construction to 4-way valves of the same brand, but may be shorter in length. From most manufacturers they are available only in single solenoid models, with either a N.O. (normally open) or N.C. (normally closed) configuration. A few manufacturers may offer them in 2-position and 3-position double solenoid models. However, most applications for 3-way valves do not require anything more elaborate than single solenoid action.

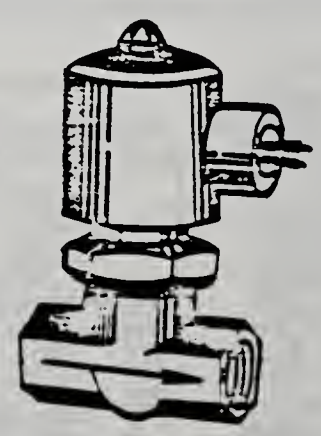
When 3-way action is needed from a spool valve the most often-used arrangement is to use a standard 4-way spool valve and install a plug in the cylinder port which is not used. One advantage is that by choosing the correct cylinder port to use, the 4-way valve may be made into either a N.O. or N.C. 3-way valve. It would be wise to check valve specifications before plugging any port on a 4-way valve. Some brands may have packings unseated or may develop spool bind if ports are permanently plugged.

3. Two-Way Solenoid Valves

Figure 1-8. Two-way solenoid valves are classed as "directional" valves, although their action is only to open and close by solenoid motivation. They are used to start and stop the flow of fluids — air, oil, water, etc. Solenoid operation permits them to be controlled from a remote location, or allows them to be wired into an automatic cycle with other electrically operated equipment. In special circuitry, shown later in this book, they can be used in groups of two, three, or four to obtain valving flexibility not possible with one 3-way or 4-way valve.



A. Spool-Type 2-Way Valve.



B. Poppet-Type 2-Way Valve.

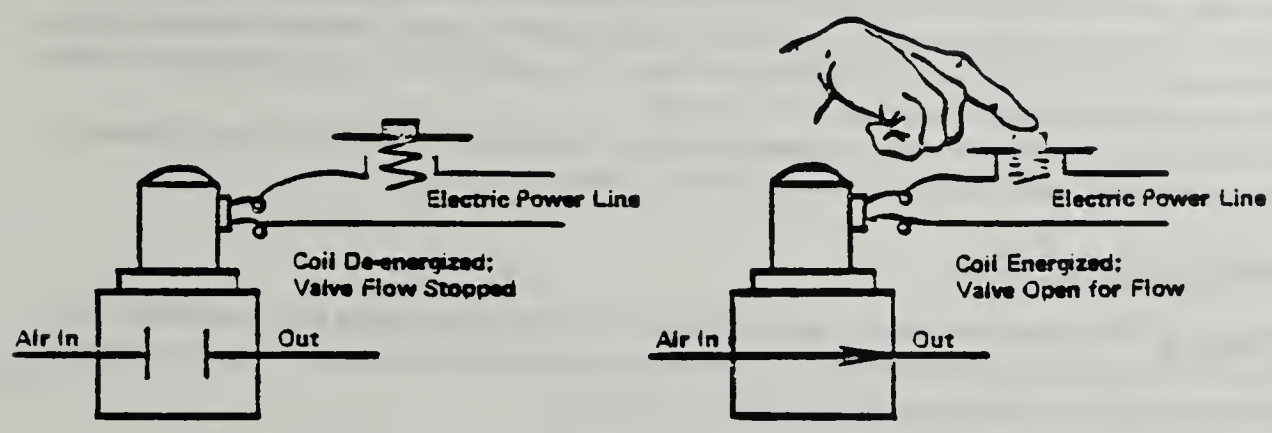
FIGURE 1-8. 2-way, 3-way, and 4-way valves may be constructed to operate either on the poppet or sliding spool principle.

Poppet action and sliding spool action are the two modes of construction most often used for construction of directional valves. An example of the general appearance of each type is given above. Poppet construction is most popular for 2-way valves, and is also used extensively for 3-way valves. Spool action is most popular for oil hydraulics and compressed air 4-way valves. Electrical and fluid circuitry is generally the same for valves of either construction.

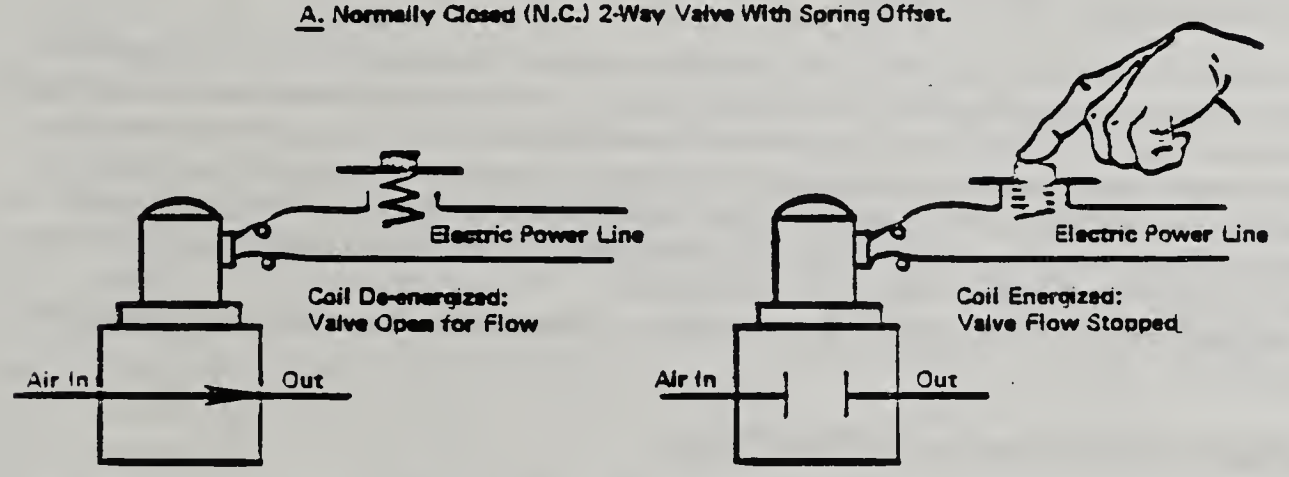
Part A Figure 1-8. 2-Way Spool Valves. Most manufacturers offer 2-way valves with only single solenoid construction, spring return. A few double solenoid models having two positions may be available.

Three-position double-solenoid 2-way valves normally are not available, since there is no practical use for a center neutral position on a shut-off valve; it is either open or closed.

Part B - Figure 1-8. 2-Way Poppet Valves. Mounting requirements may vary with the brand and nature of the valve. Some poppet valves are constructed so they can be mounted in any position, while others must be mounted with the solenoid vertically upward in order to function properly or at all. If no specific mounting information is available, the best practice is always to mount a valve of this type with solenoid up.



A. Normally Closed (N.C.) 2-Way Valve With Spring Offset.



B. Normally Open (N.O.) 2-Way Valve With Spring Offset.

FIGURE 1-9. Examples of the action of 2-way solenoid valves of the N.O. (normally open) and N.C. (normally closed) types.

Figure 1-9. Action of 2-Way Solenoid Valves. Two-way valves may be either N.C. (normally closed) or N.O. (normally open). This nomenclature refers to the flow passage through the valve when its solenoid is de-energized.

Part A of this figure shows that a N.C. valve, when de-energized, blocks fluid flow through it. When energized, fluid will flow through it in the direction of inlet to outlet or in the direction of the flow arrow marked on the valve body (if one is present). Part B of the figure shows that a N.O. valve, when de-

energized, will pass fluid flow in the direction of its flow arrow, and will be closed to flow when energized.

Imoortant Note. When selecting a 2-way poppet valve for a given application make sure you understand its flow characteristics. There are important variations between brands. Some of them will permit reverse flow (similar to check valve action) even when they are closed to flow in the forward direction. Some will not pass flow at all, or with severe restriction, in the reverse direction even when they are open to free flow in the forward direction. Some have large connections but small diameter internal orifices.

Choice of a N.O. or N.C. 2-way valve depends on the fluid action desired when the valve is energized. Sometimes either type could be used if tied in with the proper electrical contacts, and the choice may be made to obtain "fail-safe" operation; to put the fluid circuit in a safe condition if an electrical failure should occur. In most applications a N.C. valve would be preferred, as it would close, cutting off the fluid flow, if control current should fail or a solenoid coil should burn out. A notable exception is solenoid venting of a pump relief valve, in which a N.O. valve is ordinarily used. In case of electrical failure, the pump would be unloaded. See Figure 5-4, Page 95.

Valve type may also be selected on the basis of length of its on and off periods. A type is selected which requires energization over the minimum length of time.

4. Poppet-Type 3-Way Valves.

Figure 1-8. This figure may also be used to illustrate the general appearance of a 3-way valve. Such a valve will, of course, have three main ports. Electrical circuitry for 3-way poppet valves is the same as has been discussed for sliding spool 3-way valves. See Figure 1-7.

5. Directional Control Valves — 5-Way.

Ordinarily used only on compressed air, seldom on hydraulics. Their appearance may be identical to that of a 4-way of the same brand. They are constructed to have two pressure inlets, two cylinder ports, and one exhaust port. Their purpose is to operate a double-acting cylinder from a different level of input pressure in each direction. Many brands of dual exhaust air valves are suitable for 5-way service by reversing their inlet and exhaust connections, using the dual exhaust ports for dual inlet ports, and the single inlet port for a single exhaust port. For further description of 5-way valves and their applications, see "Industrial Fluid Power — Volume 1"*, Chapter 4.

Electrical circuitry for operation of 5-way valves is the same as would be used for 4-way valves of the same type.

6. Orienting Cylinder Direction with Valve Position.

If, after making an installation, the cylinder moves in the wrong direction in resoonse to a given electrical signal, its motion can be re-oriented in relation to the electrical circuit as follows:

On double solenoid valves, interchange fluid connections either at the valve or at the cylinder ports, or, interchange wiring to the two solenoid coils.

On single solenoid valves, interchange fluid connections at the valve or the cylinder ports.

On 3-way valves operating a single-acting cylinder, the normal porting of the valve must be changed. If a N.O. valve change to N.C., etc. When using a 4-way valve in 3-way service this is accomplished by connecting cylinder line to opposite cylinder port on the valve, while plugging the original cylinder port.

* *Textbook available from Womack Educational Publications.*

PROGRAM IEM

SELF-HELP EXAM

TASK # 212 - 1

DIRECTIONS:

THE PURPOSE OF THIS EXAM IS TO DETERMINE WHETHER OR NOT YOU HAVE UNDERSTOOD THE INFORMATION ON fluid components of robotic systems.

Each of the questions or incomplete statements below is followed by several words, phrases, or a series of numbers. Choose the one which best answers the question or completes the statement correctly. Place the letter associated with that choice (A,B,C or D) in the numbered blank space on your ANSWER SHEET. DO NOT WRITE ON THIS TEST!!! To master this exam you must answer 10 out of 10 items correctly, 100 %.

EVALUATION SHEET

1. Draw the graphic symbol for a solenoid operated 4-way valve.

2. Draw the graphic symbol for a double acting solenoid 4-way valve.

3. Identify the action of a 2-way valve.

4. The main difference between air and hydraulic circuits is

INTERMEDIATE OBJECTIVE

2

Identify common electrical sensors.

LEARNING STEPS (Activities)

1. Read the information sheet cited in Resource #1 to identify the electrical components of a robotic system.

2. Perform self help quiz identified in Resource #2 to assure your mastery of the subject.

3. Complete the criterion exam for the terminal performance objective.

RESOURCES

1. Information Sheet #2 starts on page 16.

2. Self-help quiz #2 begins on page

3. See your instructor for the needed TPO exam.

COMMON ELECTRICAL SENSORS (SWITCHES)

In the descriptions of switches and other electrical components to follow we have tried to give a brief and very general description of the most important components that are useful in controlling fluid power. Because of the wide variety of such components on the market we recommend the student or designer obtain amplified descriptions from electrical catalogs. Appearance of components may vary widely from the sketches shown here, according to brand, and it is beyond the scope of this text to provide a comprehensive description of all components available.

1. Definition of a Sensor.

The context in which the term "sensor" is used in this book includes any device which produces an electrical switching signal, triggered by some action of the fluid circuit. Three distinct classes of sensors are commonly used: (a), Switches which produce a switching signal when mechanically actuated by a moving part of a fluid cylinder or other machine member. Various types of limit switches fall into this category. (b), Pressure switches which give a switching signal in response to a rise or fall of fluid pressure in a pipe. Most of these are adjustable, allowing them to be pre-set to switch precisely at a given pressure level. (c), Manually operated switches actuated by an operator, such as pushbuttons and foot switches. Certain other sensors are available such as photoelectric, sonic, proximity, etc., but are less often used in fluid power applications.

2. Duty Rating of Switches.

From past experience it has been found that switches are often the first point of breakdown in an electrically controlled machine; it is very important to select them according to the duty expected of them. The use of low priced, non-enclosed, light-duty switches can only be justified in those applications where operation will be infrequent and where there is no danger of contamination from water or oil, or where switch cost is a very important factor. Good switches add to the original cost but will pay for themselves many times over with their long life and reliable operation. When selecting switches for machines operating on a continuous basis, where an electrical breakdown would be costly, the heavy-duty industrial type should always be used. It is best to obtain the advice of your electrical distributor as to the quality of switch to be purchased according to the life expectancy of the machine on which it will be used.

But even switches of the highest quality will not give reliable service unless properly mounted, and actuated with carefully designed cams. The main points to be observed are:

(a). Machine cams which actuate the switch should be designed so they contact the switch roller at the proper angle, and for high speed operation their leading edge should be shaped to give uniform acceleration to the switch arm. Cams which override the switch arm should be designed so the switch arm cannot snap back freely. See Page 115 for detailed information.

(b). It almost goes without saying that a switch should be mounted so it will be protected from physical damage if a cylinder should get out of control and override it.

(c). Switches should not be operated beyond the normal recommended travel of the actuator arm. This causes added internal stress which shortens the switch life.

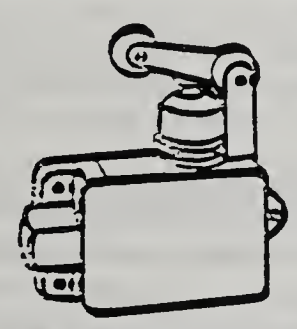
Standard Limit Switch Sensors. Figure 1-10.

Limit switch types are not limited to those shown in this figure. A complete catalog of electrical switches should be consulted for selecting the types of actuator most convenient for a given installation.

Part A, Figure 1-10. The basic snap-action switch is available with many different actuators, and is relatively inexpensive. It is intended for light duty service in a protected environment. Although the switch contacts are enclosed, they are not sealed against entry of water and oil, and the electric terminals are exposed. For hydraulic fluid power the basic switch is primarily useful on experimental or temporary set-ups, but seldom suitable on permanent, heavy-duty installations.

A. Basic light-duty switch, non-enclosed, with roller actuator.

B. Light-duty switch in protective housing. Pin actuator illustrated.



C. Light-duty switch in protective housing. Roller actuator illustrated.

D. Heavy-duty industrial type limit switch illustrated with roller arm actuator.

FIGURE 1-10. Examples of Limit Switches Having Standard Action with Spring Returned Contacts.

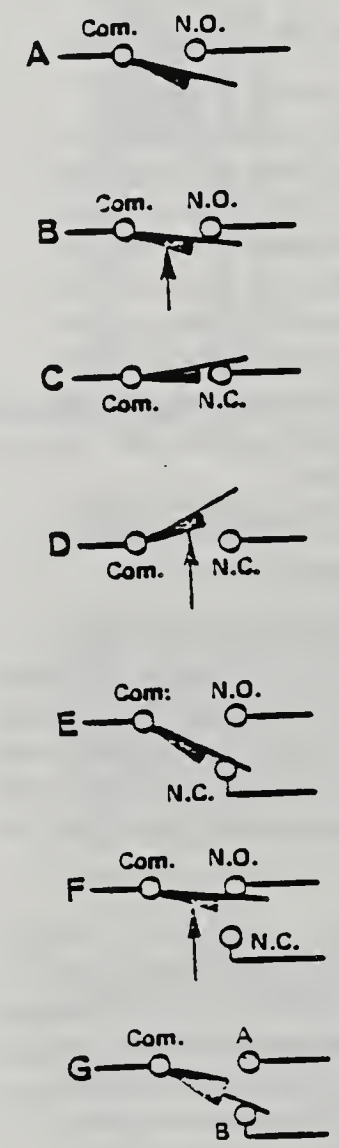
Parts B and C, Figure 1-10. The light-duty basic switch element is supplied with several different actuators in a water and oil-tight enclosure. The electrical terminals as well as the contacts are completely protected. This makes it environmentally suitable for most fluid power installations. The classification of "light-duty" for these switches does not infer they are inferior in quality. They are specifically designed for a good balance between cost and contact service. Their best application is on those installations subjected to a moderate number of switching cycles, and where the occasional replacement of a switch is not any problem. Size may also be a factor.

Part D, Figure 1-10. Heavy-duty industrial limit switches should be used on machines where the utmost in reliability is important; where a breakdown in a switch would be costly from the standpoint of lost production time. These industrial switches are considerably more expensive than the light-duty switches. They are also larger, which may present a mounting problem where space is limited. The designer must weigh advantages against disadvantages in selecting switches most suitable for a given machine. Plug-in switches are available which can be quickly replaced by removing only two screws.

CAUTION! Limit switches should always be mounted in such a manner that they cannot be damaged if the machine should accidentally overtravel, which might happen if a solenoid coil should burn out or if control current should fail. Switch mounting brackets should be designed to allow an adjustment in switch positioning.

4. Limit Switch Contacts and Terminology.

The diagrams in the chart on this page show the proper way of drawing limit switch contacts on schematic diagrams. When properly drawn, the symbols provide important information on switch action and type. An important clue is the solid triangle drawn on the switch arm. A moving cam works against this surface to open or close the contacts. Abbreviations such as N.O., N.C., Com., SPST, SPDT, etc., may be placed adjacent to the contacts for assistance to the reader in identifying the contact action. Abbreviations are defined in the chart. If the term "double pole" is used with any of the following, it indicates two separate sets of switch contacts in the same housing with a common actuator.



A. SPST (single pole, single throw) N.O. (normally open) set of contacts. Usually drawn in their "normal" state which is open, except when there is a reason for showing them in the actuated state.

B. Same contacts as Part A, drawn in their actuated state. The side arrow shows they are held closed by a cam before the start of a cycle or during standby periods. However, the position of the solid triangle on the arm, pointing away from the contacts, indicates their normal type and state as N.O. (normally open).

C. SPST (single pole, single throw) N.C. (normally closed) set of contacts, shown in their "normal" (non-actuated) state. The placement of the solid triangle shows that a cam would open them.

D. Same contacts as Part C, drawn in their actuated state. The side arrow shows they are held open by a cam before the start of a cycle or during standby periods. However, the position of the solid triangle on the arm indicates their normal type and state as N.C.

E. SPDT (single pole, double throw) contacts. Sometimes called "transfer" contacts. Placement of the solid triangle on the arm indicates which is the N.O. and which the N.C. circuit. It indicates also that the contacts are in their "normal" state.

F. Same contacts as Part E, drawn in their actuated state. The side arrow shows they are mechanically held in an abnormal state, but the solid triangle on the arm shows their normal state.

G. SPDT contacts on a maintained type (no spring) switch as in Figure 1-17, Part B. A solid triangle on both sides of the arm indicates it must be actuated in both directions. There is no N.O. or N.C. marking on its terminals because it has no "normal" condition.

Note: Abbreviations next to contacts, Com., N.O., and N.C., indicate common, normally open, and normally closed respectively.

FIGURE 1-11. Contact Arrangements for Limit Switch Sensors.

Switch contacts which have a return spring are said to be in their "normal" state when not mechanically actuated. Contacts should always be drawn in their normal state on diagrams except when a cam is holding them actuated during a standby period or between cycles. Examples will be found on diagrams in this book showing a switch in actuated condition where a cylinder, returning to home position, ends the cycle by "standing" on the switch. As soon as the cylinder has moved a short distance from home position the switch can return to its normal state.

In Figure 1-11, Part A, for example, the symbol for N.O. (normally open) switch is shown as it would usually be drawn. But if it is held in an actuated condition at the end of a cycle, it should be drawn as indicated in Part B of the illustration.

If switch contacts must be actuated in both directions, as for example a toggle-type, over-center switch, there is no "normal" position for the contacts. On the schematic, they should be drawn in the state they will be in at the end of a cycle. Their terminals may be unmarked on the switch except for the common terminal, and terminals on the drawing should likewise be left unmarked. Part G of the drawing is an example of such a switch.

Little used but sometimes available are DPDT (double pole, double throw) switches having two independent sets of transfer type contacts in the same housing, operated by the same actuator.

FIGURE 1-12.
Standard Limit Switch Fitted With One-Way Roller Actuator.

5. One-Way Roller Limit Switch.

Figure 1-12. An example of a non-enclosed limit switch having a one-way roller actuator. The actuator arm has a knee joint which folds out of the way of a machine cam approaching from the left without actuating the switch contacts. But when a cam approaches from the right, the knee joint does not bend, and the switch contacts are actuated.

This one-way action is useful on switches to be actuated at an intermediate point in a cylinder stroke. The returning cam can pass over the switch without producing a second, and unwanted signal.

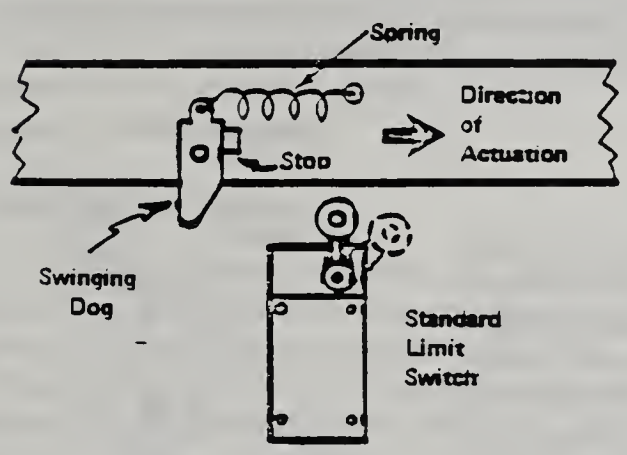


FIGURE 1-13. A spring loaded machine cam can be constructed to have a 1-way action on a standard limit switch.

Light-duty actuators of this type should be used at machine speeds of less than 50 feet per minute to obtain reasonable life. The shape of actuating cams should follow the recommendations on Pages 114 to 116.

Heavy-duty industrial limit switches may be purchased with a partial roller rotationally spring loaded, which gives the same one-way action described above. Or, a standard limit switch may be used, operated with a spring-loaded or gravity return dog hinged to the moving machine member. Figure 1-13.

In this illustration, the dog, when traveling toward the right will actuate the switch contacts, but when traveling toward the left, will fold out of the way.

Further details of one-way roller action will be found on Pages 115 and 116.

Impulse Limit Switches Help Solve Difficult Circuit Problems

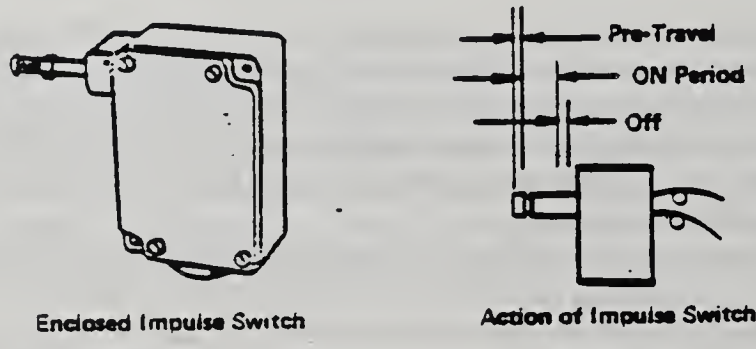


FIGURE 1-14.
A special limit switch with one-way impulse action will sometimes help solve an otherwise difficult circuitry problem.

6. Impulse Limit Switch.

Figure 1-14. The one-way impulse switch illustrated above is a special switch available to the designer for simplifying difficult circuit problems. Where applicable, it can eliminate holding relays and their associated wiring. However, it is subject to certain limitations described below, and can only be used in circuits especially designed for it.

The action is as follows: A switching signal is produced only while the plunger is traveling inward. Signal cuts off as the end of the plunger travel is reached, and remains off during return travel. Usually has one set of "transfer" contacts with one N.O. and one N.C. circuit. To illustrate the action, as soon as the plunger starts its inward travel the N.O. contacts close and remain closed until full inward travel has been completed. These contacts then open and remain open as long as the plunger remains depressed. They also remain open during return travel and when the plunger is released and returns by internal spring force. Thus, a short duration "make" is produced on the N.O. switch terminal and a short duration "break" on the N.C. terminal.

Switch Limitations: The faster its stem is actuated the shorter the switching impulse. On high speed mechanisms the impulse may be so short as to be unreliable for shifting a fluid power valve. Normally, 50 feet per minute is the maximum actuation speed, although operation may be successful up to 100 feet per minute. If machine travel is too fast for an impulse switch, the solid state impulse circuit in Chapter 6 may be used, or standard components and circuitry can be used. Any control function possible with impulse switches can be duplicated with standard components by adding holding relays.

Mounting is critical. The switch must be accurately positioned to within 1/64th of an inch. The traveling mechanism must carry the stem to full depth in order to cut off the switching signal, but must not overtravel far enough to damage the switch. Impulse switches should never be used on loose, non-precision mechanisms which might not stop precisely at the same place every time.

7. Pressure Switch Sensors.

Figure 1-15. A pressure switch is teed into the fluid line, which may be air, hydraulic, or vacuum. Its working element responds to a rise or fall of fluid pressure to open or close a set of electrical contacts when a certain pressure level is reached. Most pressure switches are adjustable over a limited range of fluid pressure, and may be purchased for the range desired.

The pressure sensing element is often a Bourdon tube, similar to that used in some pressure gauges. It is a curled tube of bronze, steel, or stainless steel, closed at one end,

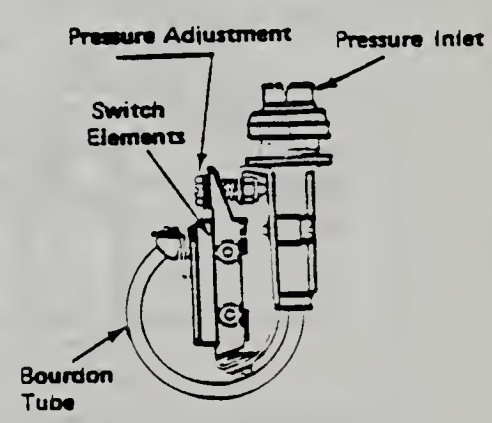


FIGURE 1-15. Bourdon Tube Pressure Switch.

into which fluid pressure is introduced. Internal fluid pressure tends to "uncurl" the tube. This uncurling movement is linked to a set of contacts. Other sensing elements may also be used, as a spring-loaded bellows of brass, bronze, steel, or stainless steel for low pressure ranges, or a spring loaded piston for high pressure ranges. And for very high pressure ranges, two spring loaded pistons of slightly different areas produce opposing forces. The low range resultant force from these pistons is applied to a sensing mechanism operating a set of electrical contacts.

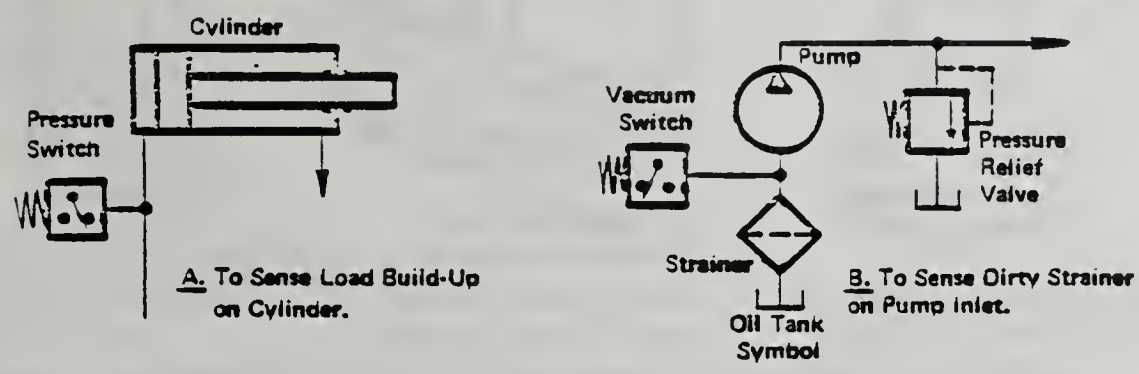


FIGURE 1-16. Examples of Pressure Switch Applications.

Figure 1-16. Pressure switches may be installed in various parts of a fluid system to produce an electrical switching signal in response to a rise or fall in fluid pressure. One of the most useful applications is shown in Part A. The pressure switch, of suitable range, is teed into a cylinder line to give a switching signal when load against the cylinder piston has caused fluid pressure behind the piston to rise to the adjustment setting of the pressure switch. This switching signal can be used to reverse the cylinder travel or to start a second action in an automatic cycle.

In Part B, a vacuum switch is teed into the inlet (suction) side of a hydraulic pump. Its contacts may be tied into an electric warning signal if pump suction should rise to a dangerous level due to build-up of dirt on the inlet strainer. Other examples of pressure switch use are shown in later chapters.

Terminology. Switching contacts in a pressure switch are sometimes called "make-on-rise" or "break-on-rise". These terms describe switch action as fluid pressure increases. Comparing this terminology with that of limit switches, "make-on-rise" is equivalent to N.O. (normally open), and "break-on-rise" is equivalent to N.C. (normally closed).

8. Toggle-Type Switches.

Toggle action, as applied to switches, may be described as an over-center snap action that rapidly opens or closes a set of contacts. It further implies that there is no return spring; the contacts must be mechanically actuated from one position to the other. They do not have a "normal" state to which they return by spring force after external actuating force has been removed.

Several terms are used to describe this kind of switch action: "Flip-flop" is used in fluidics to describe a similar action. "Maintained" action is another term frequently used.

Figure 1-17. Several types of "toggle" or "maintained" action switches are available for electrical control of fluid power. Part A shows a miniature switch designed for finger operation, usually to be

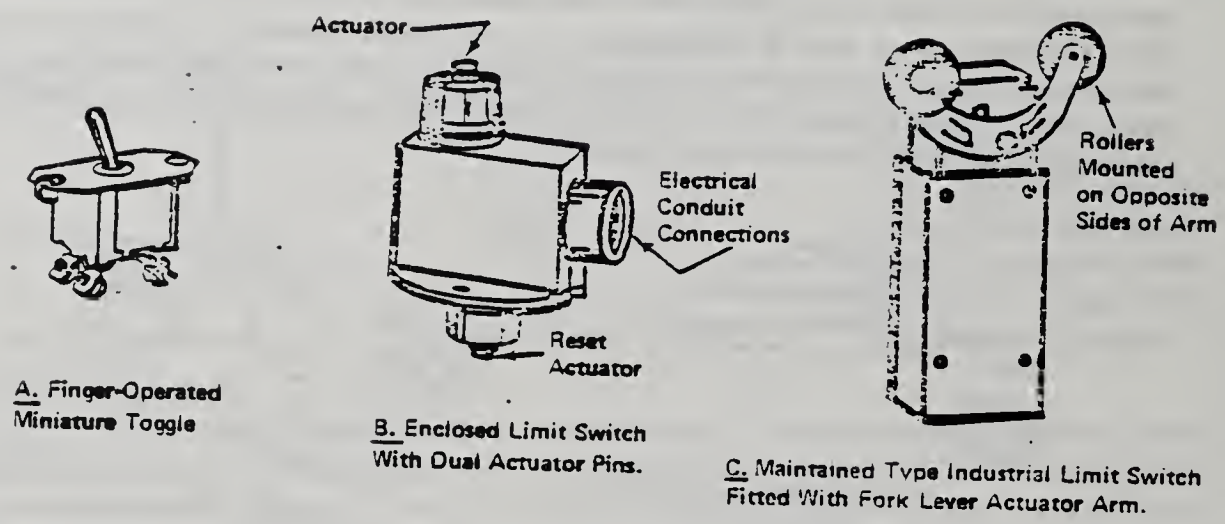


FIGURE 1-17. Examples of Switches Having "Maintained" or "Toggle-Type" Action.

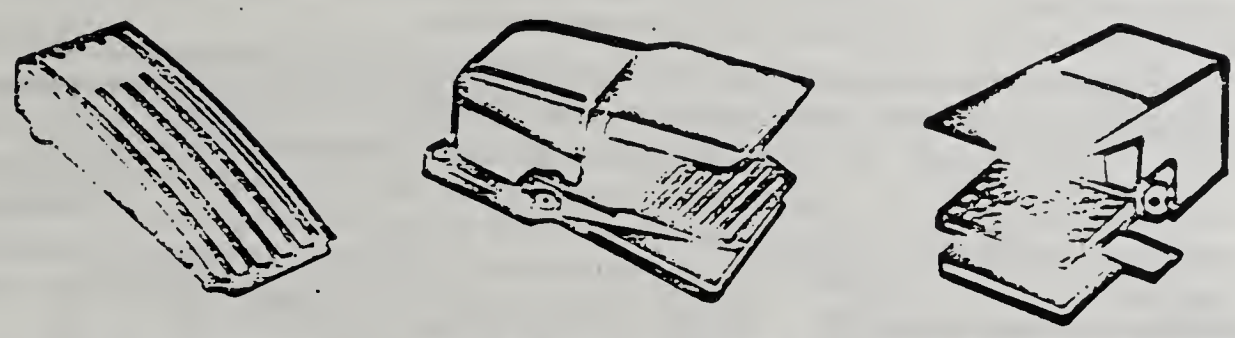
mounted on a control panel. It can also be mounted on a machine for actuation by a moving cam, subject to certain operating limitations described in a later chapter, Page 58, and must be protected against overrun by the cylinder. Its use as a cam actuated switch should be limited to light duty and experimental applications, as it is not built ruggedly enough to stand up long in this service. True toggle switches, with their over-center action, are necessarily limited to two working positions. Similar switches are available having a center neutral, and these usually have double toggle action, or simply a spring loaded detent.

Part B shows a maintained type switch in protected enclosure. Two stems, one on top, the other on the bottom, toggle the contacts from one position to the other. There is no internal return spring. The contacts remain in the last position to which they were toggled until a thrust from the opposite stem shifts them to their other position.

Part C shows a heavy duty industrial limit switch fitted with a fork lever actuator arm. The basic switch to which this arm is fitted must have a maintained action; no spring return. The most often used fork lever arm used in fluid power has two rollers mounted on opposite sides of the lever. Each roller is actuated by a different cam on the machine. This is known as an "offset" type of fork lever. An alternate fork lever is available with both rollers mounted on the same side of the lever, and may be used on applications where both rollers are to be actuated by the same cam. Diagrams in Chapter 3 show how the fork lever switch may be used.

9. Foot Operated Switches.

Figure 1-18. Part A shows a light duty foot switch which may be actuated by an operator's foot, knee, hand, elbow, or arm. It is available with choice of several operating arrangements including: (a), foot actuation with: spring return, either N.O., N.C., or transfer contacts; (b), with pedal hinged at the center, with centering springs or center detent, and with two sets of contacts for toe (forward) or heel (backward) operation for switching two different circuits; (c), two contact sets at different depths of pedal travel; the first pedal movement actuates the first set, then as the pedal is pressed further, the second set is also actuated. Light duty switches of this general type are not usually sealed; they are primar-



A. Light-Duty Foot Switch in Open-Type Housing.

B. Light-Duty Switch Element Enclosed in Watertight Housing.

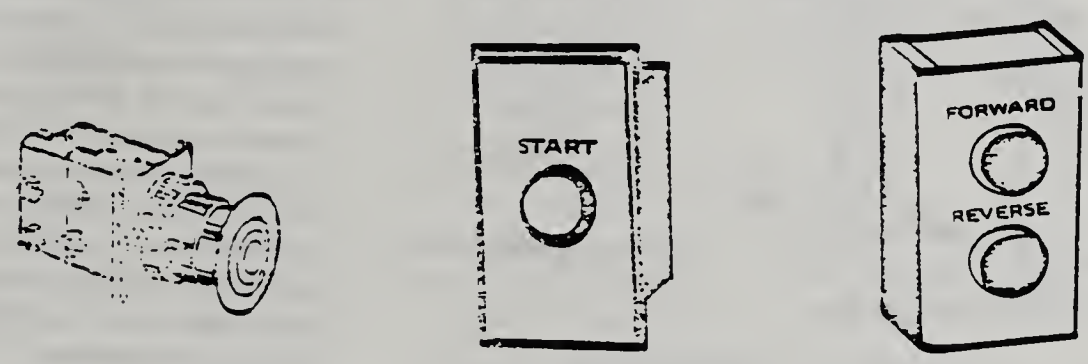
C. Heavy-Duty Industrial Foot Switch With Toe Guard & Latch.

FIGURE 1-18. Examples of Foot Operated Switches.

ily for portable use, and are connected to the main control box with rubber covered cord or flexible cable.

Part B illustrates one brand of light duty switching element enclosed in a ruggedly constructed iron housing sealed against entry of water and oil. Available with or without a guard to safeguard against actuation by a falling object. Enclosed switches usually have an electrical conduit connection sealed for permanent installation, but may be installed for portable use by using a waterproof cable properly sealed at the conduit opening.

Heavy duty models, Part C, have rugged frame, usually cast iron, to resist a considerable amount of abuse. Switching elements have a high amperage rating and are completely enclosed against entry of dirt, water, and oil. They may be obtained with or without toe guard and with or without latch. Latch locks treadle down after it is depressed. Foot pressure on the latch lever unlocks the treadle. Some latching switches unlock by pressing the treadle a second time. Wiring is through a conduit connection.



A. Industrial Pushbutton for Panel Mounting.

B. Momentary Pushbutton in Enclosure.

C. Momentary or Maintained Pushbutton in Enclosure.

FIGURE 1-19. Examples of Electrical Pushbuttons.

10. Electrical Pushbuttons.

Figure 1-19. Part A pictures an industrial type momentary pushbutton designed for mounting in a control console. This illustration shows a stack up of two sections giving a total of four independent sets of contacts, choice of N.O. or N.C. Transfer type contacts are made by combining one N.O. and

one N.C. set of contacts. Any reasonable number of sections can be stacked together, although the required operating force increases with the number of sections stacked. In fluid power control, except on extremely involved circuitry, seldom more than one section is required. Push knobs can be obtained in several colors for easy color coding; some brands can be purchased with lighted buttons. A choice of knobs is also available from small diameter miniature knobs to large diameter mushroom knobs. A further choice is with key locks to prevent unauthorized operation.

In Part B, individual enclosures can be used for pushbuttons which are not part of a control console. The buttons pictured in Part A are mounted in enclosures designed for one to four or more buttons.

Part C. Pushbutton pairs are of two types: Momentary buttons, each button with spring return, for such operations as "Forward - Reverse", "Up - Down", "Start - Stop", and others, and maintained buttons which are mechanically interlocked one with the other. Pressing one button locks it in while unlatching and releasing the opposite button. Electrical circuitry is often much simpler with maintained, mechanically interlocked buttons, but momentary buttons have the advantage of remote control capability from several control points.

11. Rotary Selector Switches.

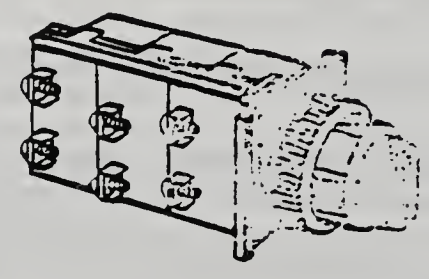
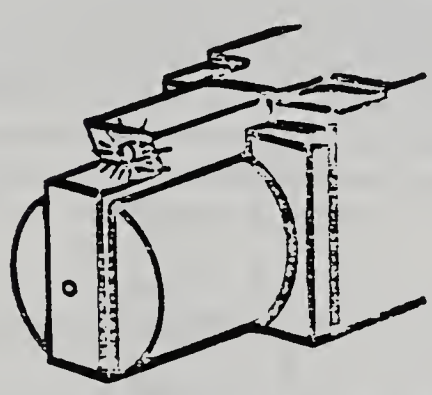


FIGURE 1-20. Industrial Rotary Switch.

Figure 1-20. For electrical control consoles this type of rotary switch is normally used. It is available in 2-position and 3-position models and with any reasonable number of contact sets by stacking sections on the basic switch. The illustration pictures a 3-section stack. A choice is offered of 2-position, spring return, 3-position spring centered or detented. Available also with key lock.

Where the above switch is not adequate, rotary switches for the electronic industry are available with up to 25 or more rotary positions.

12. Indicator Lamps.



B. Lamp on Solenoid Coil.

A. Panel Mounted Lamp.

FIGURE 1-21. Indicator Lamps.

An indicator lamp permanently wired across each solenoid valve coil provides the troubleshooter with a quick means of pinpointing trouble in event of an electrical breakdown. If mounted on an operator's panel they should be mounted in order of their actuation. Since they are not a functional part of the electrical circuit, their addition is left to the discretion of the designer.

On spring centered and spring return solenoid valves, the lamps may be wired directly across each solenoid coil. For addition to momentary type 2-position valves, see Page 133.

Most hydraulic valve manufacturers can now supply their solenoid valves with indicator lamps built into the solenoid assembly. This feature costs a little extra when the valves are purchased but is valuable as a troubleshooting aid to quickly determine whether or not the electrical circuit is working.

OTHER ELECTRICAL COMPONENTS

In this section we have selected for description a few of the many electrical devices available to the circuit designer. Those selected are the ones most often used in electrical control of fluid power. They are available from many sources and may sometimes vary in physical size and appearance from the illustrations shown; while still having identical electrical action.

1. Relay.

A relay consists of an electromagnet with a moving armature. One or more sets of electrical contacts are actuated by closure of the armature as the relay coil is energized. These contacts are said to be in their "normal" state when the magnet coil is de-energized, and in their "actuated" state when the coil is energized.

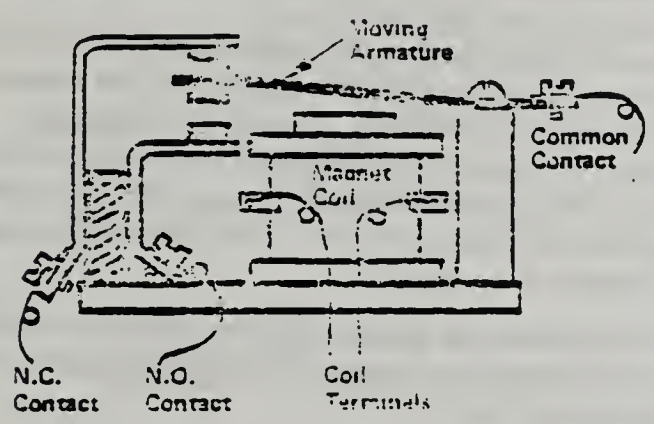


FIGURE 1-22A. Electrical Relay Shown With Coil De-energized.

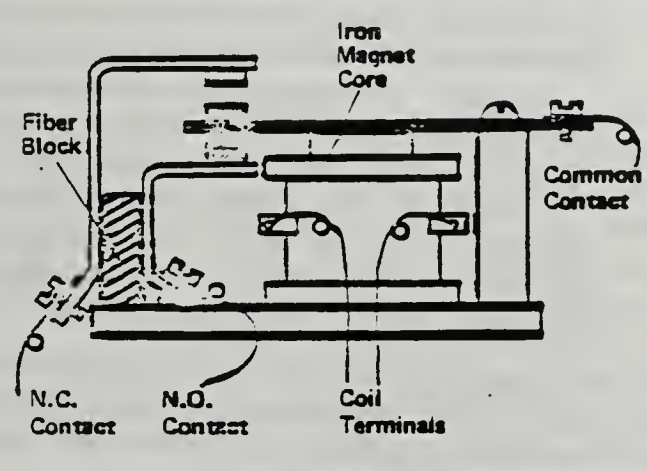
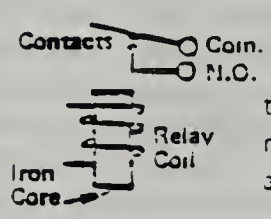


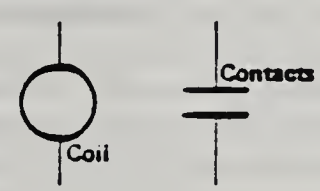
FIGURE 1-22B. Same relay with coil energized. Contacts have changed position.

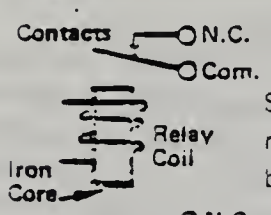
Types of Relay Contacts. Industrial relays having heavy-duty contacts are usually furnished with only two types of contacts — normally open and normally closed. Several sets of either type can be mounted on one coil and armature structure. Proper marking of coil and contacts is shown on Page 32.



Normally Open (N.C.) Contacts

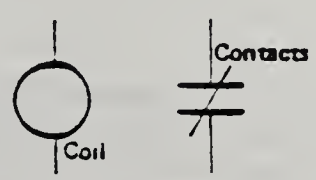
When the relay coil is energized, the contacts close. Picture symbol of relay is shown to the left, standard schematic symbol to the right, with a circle for the coil magnet and a set of parallel bars representing the N.O. contacts.

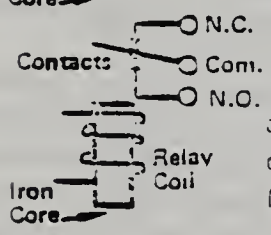




Normally Closed (N.C.) Contacts

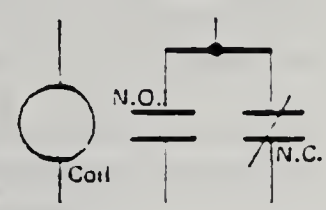
When the relay coil is energized, the contacts open. Standard symbol for schematic diagrams is shown to the right, with a circle for the coil magnet and a set of parallel bars with a slash showing the contacts are N.C. type.





Transfer Type Contacts

Transfer type contacts have single pole double throw action. While available on some relays, they are constructed on an industrial relay by combining a N.O. set with a N.C. set of contacts as shown in the diagram to the right.



2. Relay Applications.

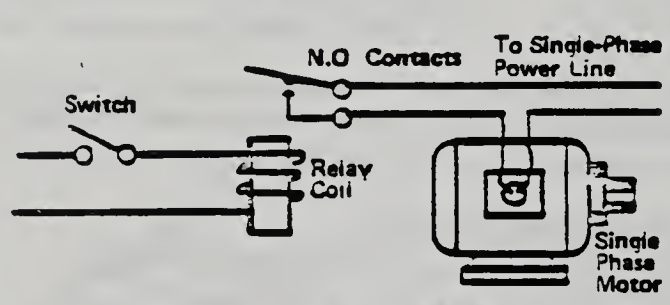
The designer should use good judgement in choosing relays for a control circuit, according to the duty expected of them. The sharp impact of the relay armature tends to be destructive, so any relay will have a definite life expectancy. Light-duty relays, with their economy of first cost, may be a wise choice for experimental circuitry and possibly on machines which are operated very occasionally. But on industrial machines which operate on a high duty cycle and where long and trouble-free life is demanded, heavy-duty industrial relays should always be used. While their first cost is higher, they will pay for themselves many times over by reducing the service problems.

Plug-in relays are available and are useful for compact console construction and to facilitate replacement of relays. They have an advantage of being sealed against dirt and water. But they are usually light-duty relays which are intended only for low-current control circuits.

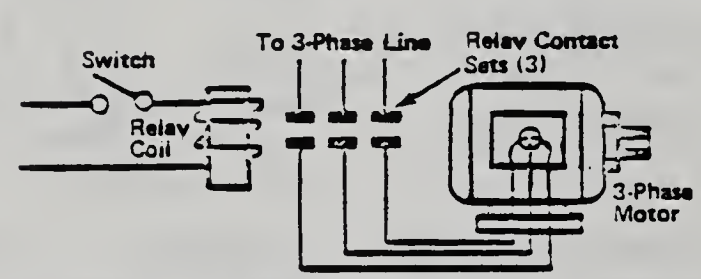
"Contactor" is another term for a relay. In common usage a contactor is considered to be primarily a power handling device for switching components which operate at a high power level, and a relay is usually considered to be a control device operating at a low power level. (Usually low amperage).

It almost goes without saying that the designer in ordering relays must specify the number of contact sets and their type, that is, N.O. (normally open) or N.C. (normally closed). He must also specify the coil voltage and frequency (if for A-C). He must also make certain that the contact sets on the chosen model have sufficient rating for the voltage and current to be handled.

Figure 1-23. In the four application sketches here and on the following page are shown the more important uses of relays on machines using fluid power. Relays are essential on all electrically controlled fluid power machines except those on very simple applications.



A. Relay Operating a Single-Phase Device.



B. Relay Operating a 3-Phase Device.

FIGURE 1-23A. As a power handling device, relays and contactors may be used to switch high power single-phase and 3-phase loads.

Figure 1-23A. Power Handling. Contactors rather than control relays are normally used for making and breaking high current loads. The relay coil operates on a very low power level and can be controlled with small limit switches and pushbuttons. Assemblies of several sets of contacts can be obtained on each contactor to switch single-phase or 3-phase loads at the same or a different voltage than used on the relay coil.

Examples of contactors on 3-phase loads are magnetic motor starters for electric motors driving air compressors, hydraulic pumps, or drilling units. This application is discussed on Pages 150 to 153, Chapter 9.

Electric immersion heater elements are controlled with thermal switches through contactors. Heaters may be installed under the oil level of hydraulic tanks for overnight use in cold climates.

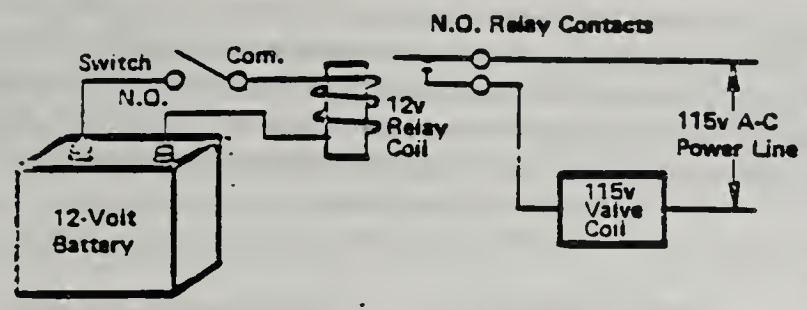


FIGURE 1-23B. A relay or contactor may be used to "interface" from one type of power to another.

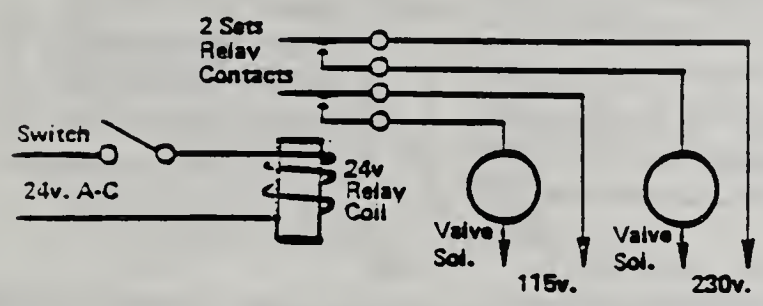


FIGURE 1-23C. Several independent power circuits may be simultaneously switched with relays.

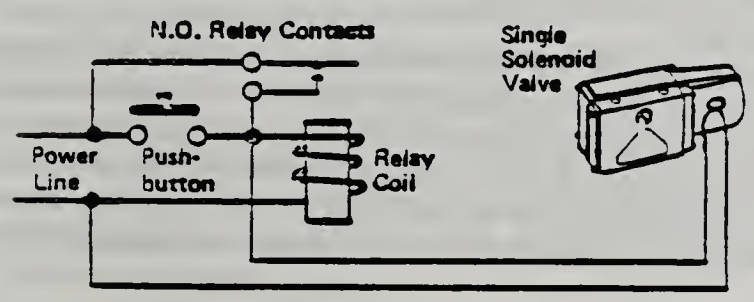


FIGURE 1-23D. Current can be maintained on spring return or spring centered solenoid valves.

Figure 1-23B. Transition. Relays or contactors may be used as intermediary devices for coupling two circuits which operate at different voltage or frequency levels, between D-C and A-C circuits, or between single-phase and 3-phase. They transmit electrical signals from one circuit to the other while keeping the two circuits from intermingling. In this sense a relay is acting as an "interface" device for a purpose similar to that described for fluidic interface devices. See Page 173.

Figure 1-23C. Isolation. Relays are not only used to isolate a coil circuit from a contact circuit, but may be used to isolate and switch loads of different characteristics. As illustrated here, two loads, one operating at 115 volts, the other at 230 volts are simultaneously switched with one relay. The relay may obtain its coil voltage from either of these two sources or from an entirely different source.

Figure 1-23D. Electrical Lock-In. An important use of a relay is to hold current on a solenoid valve after it has been momentarily energized from a pushbutton. To release the relay and solenoid valve, the power circuit must be momentarily interrupted. Details are given in the following description and in many circuits to follow, starting with Figure 3-3, Page 40.

3. Holding Relay Principle.

Any relay or contactor becomes a "holding relay" when wired through its own contacts in such a way that the armature will lock closed electrically after the coil is momentarily energized. The locking action is obtained by holding current on the coil and not by mechanical action as is the case with certain special relays which have a mechanical latch to lock the armature closed, and have a second coil to release the armature when momentarily energized. These latter are not classed as holding relays; they are usually termed "latching relays". An example of their use is on Page 133, Figure 7-22.

In electrical diagrams holding relays are often called "control relays" and are designated with Symbols 1-CR, 2-CR, 3-CR, etc. Contacts operated by their coils are designated in a similar manner as explained on Page 32.

The lock-in action of a holding relay is one of the most important principles to understand and use when designing electrical control circuits. It is especially useful for operating spring action solenoid valves — spring return and spring centered — both air and hydraulic, from momentary pushbuttons. It is used almost universally in magnetic motor starters because it will permit the starter to be remotely operated from more than one location; mechanical lock-in start/stop buttons are limited to 1-point control.

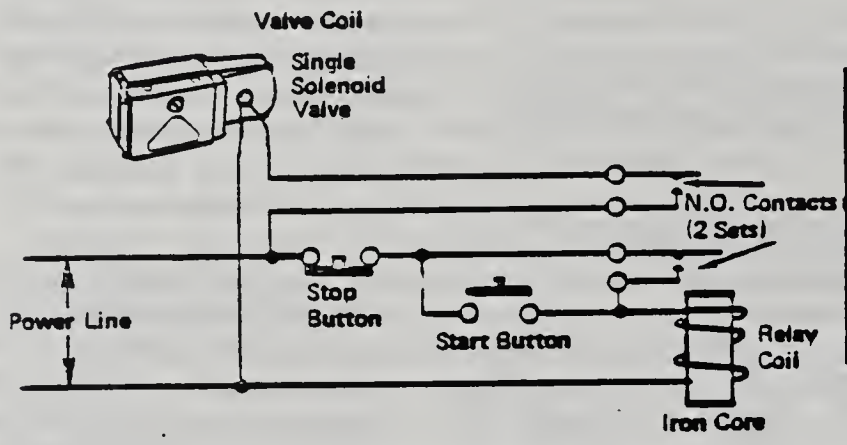


FIGURE 1-24. Electrical lock-in action of a "holding relay" in operation of a single solenoid air or hydraulic valve.

Figure 1-24. Holding relay action is shown pictorially in this diagram. Later, on Page 40, the holding relay is shown with standard graphic symbols in Figure 3-3.

The purpose of using a holding relay to operate a spring action solenoid valve is to keep current on the valve coil — to keep its spool shifted — even though the initial starting signal is not maintained. Circuit action in the above diagram is as follows:

When the "Start" pushbutton is pressed, the relay coil becomes energized, which closes both sets of contacts. The lower set — the holding contacts — now by-passes the pushbutton. The button can be released and the relay coil remains energized from current supplied through these lower contacts. The solenoid valve receives its current through the upper set of contacts. To release the relay coil and solenoid valve, the holding circuit must be interrupted by momentarily pressing the "Stop" pushbutton. This stops current flow to the coil, de-energizing the magnet, and all contacts open by spring action.

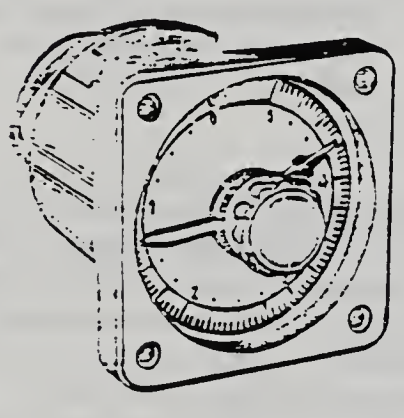


FIGURE 1-25. Adjustable Re-Set Timer (Panel Mounted Type).

4. Re-Set Electrical Timers.

Figure 1-25. May be used in a fluid power control system to delay any action such as start-up of a cylinder, or to establish a "dwell" period at one end of a cylinder travel before start-up in the opposite direction. This delay or dwell can range from a few seconds up to several hours in the case of a curing cycle.

A re-set timer is one which starts timing from zero reference when energized. At the end of the set time period its contacts are activated. When the timer motor is de-energized, an internal spring returns the mechanism to zero time reference ready for the next cycle, and re-sets the contacts to their original condition. It may have any reasonable number of independent contact sets actuated from one timing motor. It is available in a wide selection of time delay ranges.

Other manufacturers may offer re-set electrical timers having an appearance quite different from that shown in the illustration but having essentially the same electrical action. Since there is such a wide variety of timers on the market, the designer should, if considering the use of one, obtain catalogs from several manufacturers to select the one most suitable for his application.

Motor driven timers use a small self-starting synchronous electric motor as a timing element. Others may use electronic or solid state components, with voltage build-up on a capacitor as the timing principle. Still others may use a restricted air flow through an adjustable orifice to obtain a time delay.

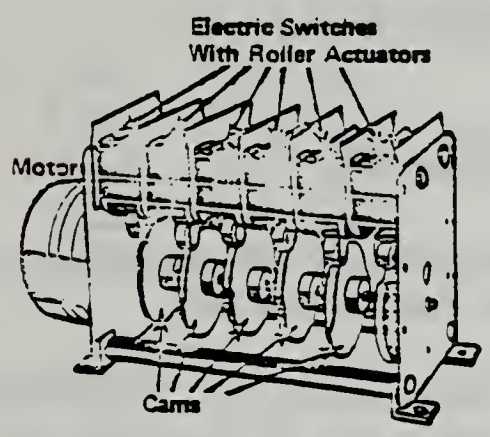


FIGURE 1-26. Program Timer

5. Program Timers.

Figure 1-26. A program timer has a set of cams and switches operated by the rotation of a small synchronous electric motor. This kind of timer does not re-set when de-energized. It picks up from where it previously stopped. It runs always in one direction and usually is arranged to stop through action of internal switching at the end of each complete revolution of the cams. When energized again, either from a momentary or maintained signal, it runs through another complete revolution and stops.

Its application to control of fluid power cylinders is to successively energize and de-energize several solenoid valves in the correct time sequence. See hydraulic circuit on Page 119.

In the illustration the timer is shown with several circular cam assemblies, each of which actuates a lever arm limit switch having one set of transfer type contacts. Each cam assembly has "split" cams: that is, two similar cams are mounted next to one another. Each of these cams can be rotated on the shaft with respect to the other to lengthen or shorten the "ON" or "OFF" time of the associated limit switch. Each cam assembly (of two split cams) can also be positioned rotationally with respect to other cam assemblies to operate the limit switches in the correct sequence.

Timers may be constructed by the user to suit special applications. Several circuits are shown on Pages 126 and 127 to cause the drive motor to stop automatically at the end of each revolution.

Through the use of program timers, an otherwise complicated electrical control circuit can be reduced to very simple terms.

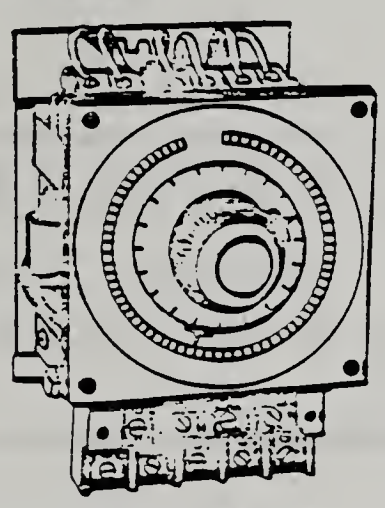


FIGURE 1-27. Example of Electric Counter (Panel Mounted Type).

6. Electric Counters.

Figure 1-27. An electric counter is a form of relay in which the contacts open or close after a pre-set number of electric impulses have been received. It is useful in fluid power control for stacking or packaging, in which a cylinder is to start after a certain count has been reached. Since a counter is used principally in control circuits, it is normally provided with only one set of transfer type contacts. See Page 26.

Some counters are built to automatically re-set after the desired count has been reached, and other types must be manually re-set before the start of each cycle.

EVALUATION SHEET

SELF-HELP QUIZ #2

- **SUBJECT:** PNEUMATIC COMPONENT SELECTION & IDENTIFICATION

- **OBJECTIVE:** To determine and identify the required components required in a pneumatic circuit

- **MATERIALS NEEDED:**
  1 - BRAT500 PNEUMATIC TRAINER
  1 - Valve
  1 - Cylinder (single action, spring return)
  1 - Air line hose with fast disconnect

- **PROCEDURE:** Select the required components to complete the pneumatic ciricut shown in illustrations 1 & 2 and advance and retract a cylinder manually.

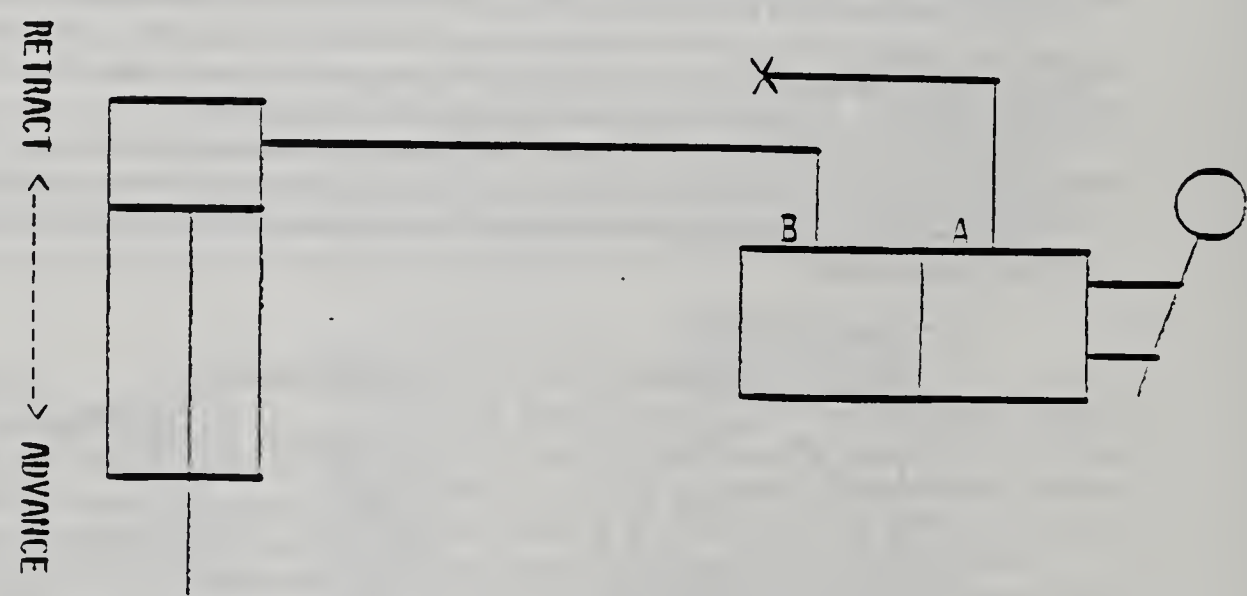


ILLUSTRATION # 1

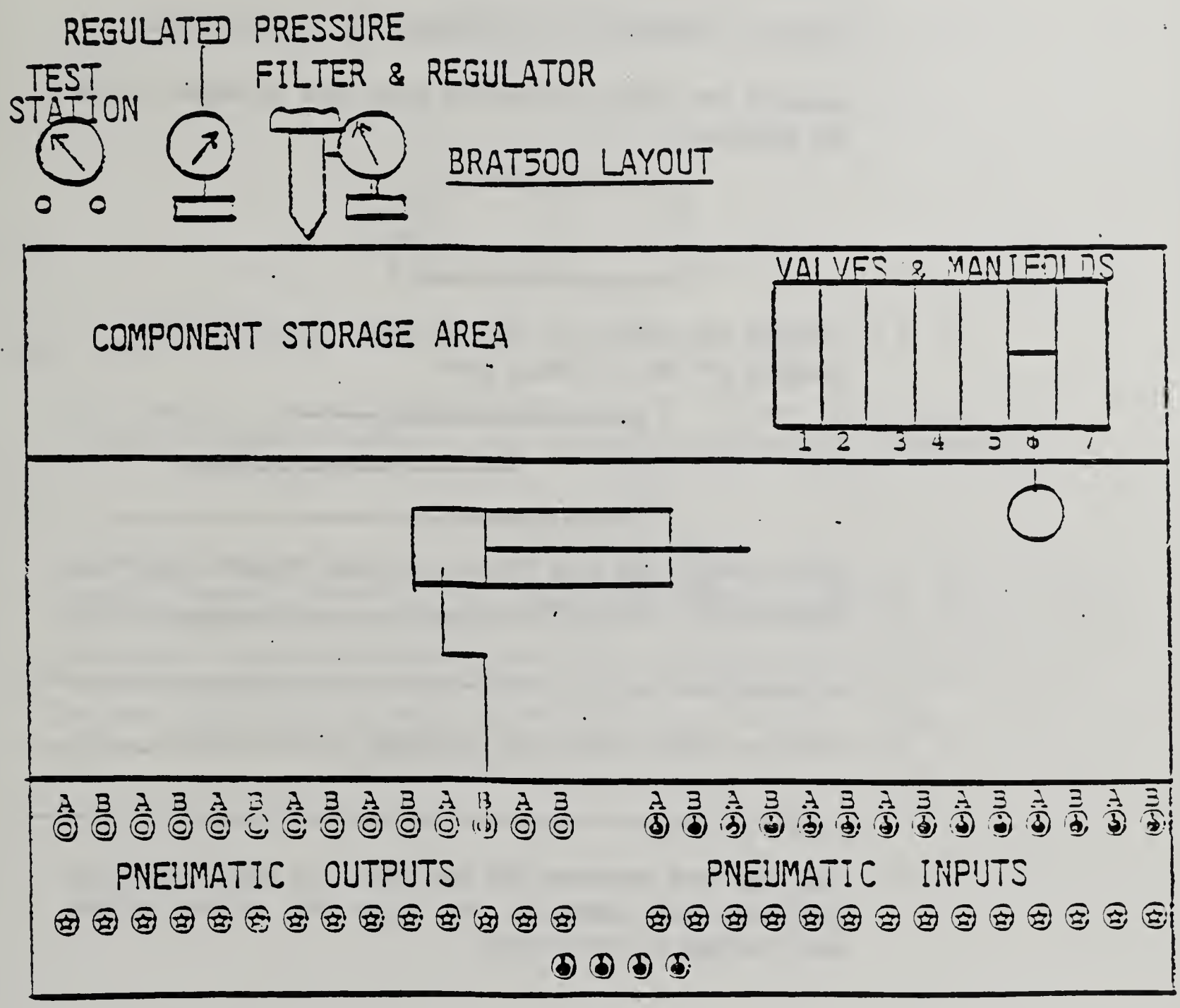
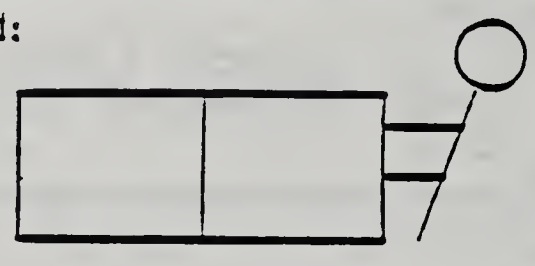


ILLUSTRATION # 2

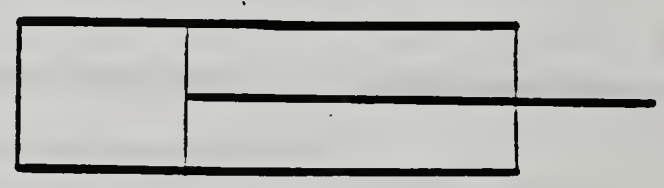
CIRCUIT TEST PROCEDURE

✓ ☐ 1 - Check all connections as indicated in illustrations

☐ 2 - Complete the symbol indicating what type of manual valve you selected:



☐ 3 - Complete the symbol for the cylinder indicating the location of the air input port:



☐ 4 - Apply 40 PSI, and move the valve lever forward. Describe what action took place: _____

_____

☐ 5 - Move the valve lever back, what action took place: _____

_____

☐ 6 - Once you have observed and performed the above functions, disconnect the components and return them to the storage area located on the trainer.

PROGRAM INDUSTRIAL ELECTRICAL MAINTENANCE

CRITERION EXAM

TASK = 212

DIRECTIONS:

THE PURPOSE OF THIS EXAM IS TO DETERMINE WHETHER OR NOT YOU HAVE UNDERSTOOD THE INFORMATION ON FLUID AND ELECTRICAL COMPONENTS.

Each of the questions or incomplete statements below is followed by several words, phrases, or a series of numbers. Choose the one which best answers the question or completes the statement correctly. Place the letter associated with that choice (A,B,C or D) in the numbered blank space on your ANSWER SHEET. DO NOT WRITE ON THIS TEST!!! To master this exam you must answer 5 out of 5 items correctly, 100 %.

EVALUATION SHEET

CRITERION EXAM

TASK 212

Please answer the following questions:

1. What is meant by a directional valve?

2. Define electrical sensors.

3. The basic electrical component of a limit switch is _____
_____.

4. Draw the symbol for AM SPDT switch and define its "normal" position.

5. Draw the schematic diagram for a circuit which starts a motor and keeps it running after the operator removes their hands.

LAKE
COUNTY
AREA
VOCATIONAL
CENTER

COMPETENCY-BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

STUDENT LEARNING GUIDE

Produced By M.H. WHITMER Date 4/85

TASK: CONNECT FLUID SYSTEM VALVES

PURPOSE: You must understand how to connect fluid system valves into a circuit to achieve a desired action. The intermediate objectives under this task presents the method of connecting valves to help you achieve the needed understanding. The modern electrical maintenance person knows how to connect valves into the circuit for proper operation. Connecting valves provide the measns of control which makes the rest of the fluid system operate.

Program	Task	Est.Time	Prereq.
17.1002	213	2 hrs.	212

dmm

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME _____ SOCIAL SECURITY NUMBER _____

LENGTH OF CONTRACT (NORMAL TIME IN HOURS) _____

2. TERMINAL PERFORMANCE OBJECTIVE

Given the material, design and needed tools, you will connect pneumatic valves in a fluid system. You must score 100% on the performance checklist for this objective.

2a. INTERMEDIATE OBJECTIVE(s)

1. Connect manually piloted valves.
2. Connect pneumatic piloted valves.
3. Connect electric piloted valves.
4. Connect ~~quick~~ exhaust valves.

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____. I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

Student's Signature _____

Instructor's Signature (verifies competency) _____

Program	Task	Page
17.1002	212	2

INTERMEDIATE OBJECTIVE #1

Connect manually piloted valves.

LEARNING STEPS (Activities)

1. Review Learning Guide in Resource #1 to recall valve action.
2. Complete the procedure cited in Resource #2 to see how valves are connected.
3. Complete the circuit testing cited in Resource #2 to assure mastery of the subject.
4. Proceed to the Intermediate Objective cited in Resource #3.

RESOURCES

1. Learning Guide 212 presents valve actions and is available from your instructor.
2. Information Sheet #1 begins on page #4.
3. Procedure Sheet #1 begins on page 6 and is entitled "Manual Circuit Tes
4. Intermediate Objective #2 begins on page 7.

LABORATORY ACTIVITY 6

- SUBJECT: PNEUMATIC VALVES
- OBJECTIVE: To operate a pneumatic valve manually
- MATERIALS NEEDED: 1 - BRAT500 PNEUMATIC TRAINER
  1 - Two position lever operated valve
- PROCEDURE: Using the above listed components, set up the pneumatic circuit as shown in illustrations 1 & 2

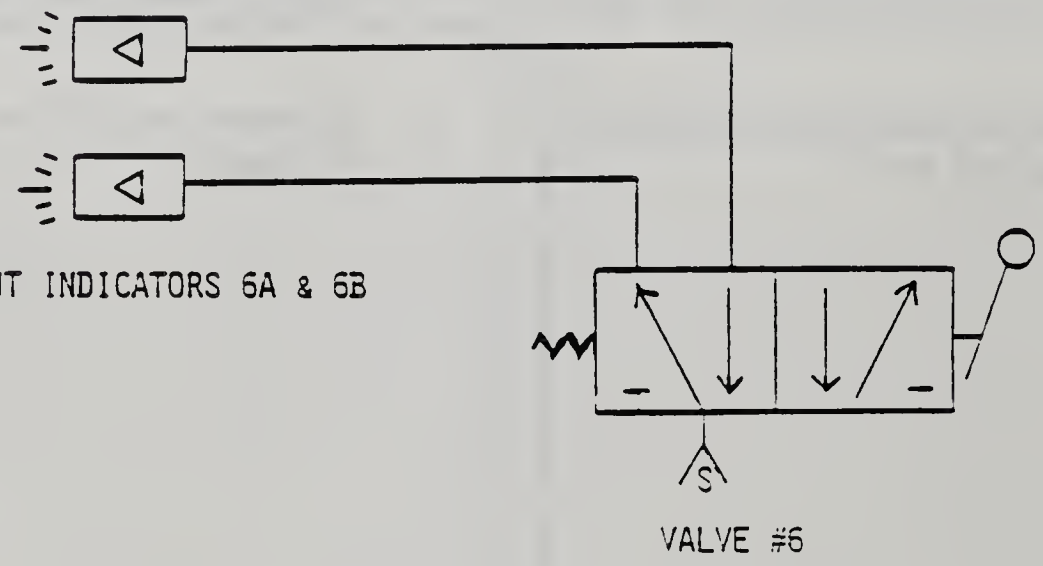


ILLUSTRATION #1

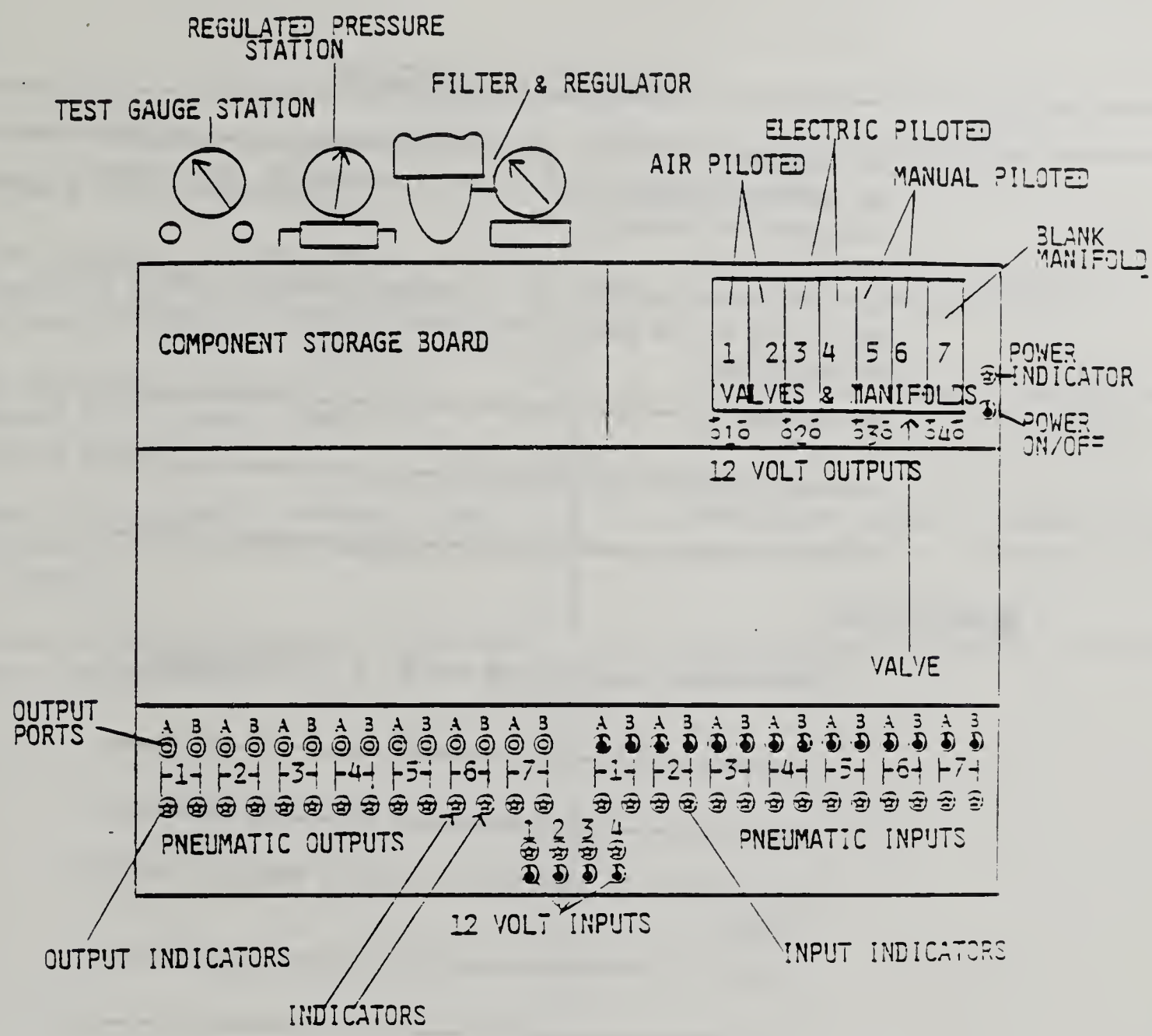


ILLUSTRATION #2

CIRCUIT TESTING PROCEDURE

1 - The components for this activity are internally connected. ie the outputs from valve NO. 6 are connected to the output indicators NO. 6A & 6B.

2 - Move the lever operator of valve NO. 6 forward; then back again. How do the output indicators respond to actuation of the valve?

_____

_____

_____

OBSERVATION:

- What takes place as the valve is shifted manually?

_____

_____

- List three (3) reasons for using a manually operated valve.

1. _____

2. _____

3. _____

INTERMEDIATE OBJECTIVE #2

Connect pneumatic piloted valves.

LEARNING STEPS (Activities)

1. Review Student Learning Guide cited in Resource #1 to recall piloted valve action.
2. Read Information Sheet cited in Resource #1 to learn about air operated valves.
3. Complete the circuit testing cited in Resource #2 to assure mastery of the circuit.
4. Proceed to the Intermediate Objective cited in Resource #3.

RESOURCES

1. Student Learning Guide #212 is available from your instructor.
2. Information Sheet #2 begins on page 10 and is entitled "Pneumatic Valve.
3. Procedure Sheet #2 begins on page 1 and is entitled "Pneumatic Valves.'
4. Intermediate Objective #3 begins on page 11.

- SUBJECT: PNEUMATIC VALVES
- OBJECTIVE: To operate a pneumatic piloted valve using pneumatic input signals
- MATERIALS NEEDED:
  1 - 3RAT500 PNEUMATIC TRAINER
  1 - Two position pneumatically piloted valve
- PROCEDURE: Using the above listed components, set up the pneumatic circuit as shown in illustrations 1 & 2.

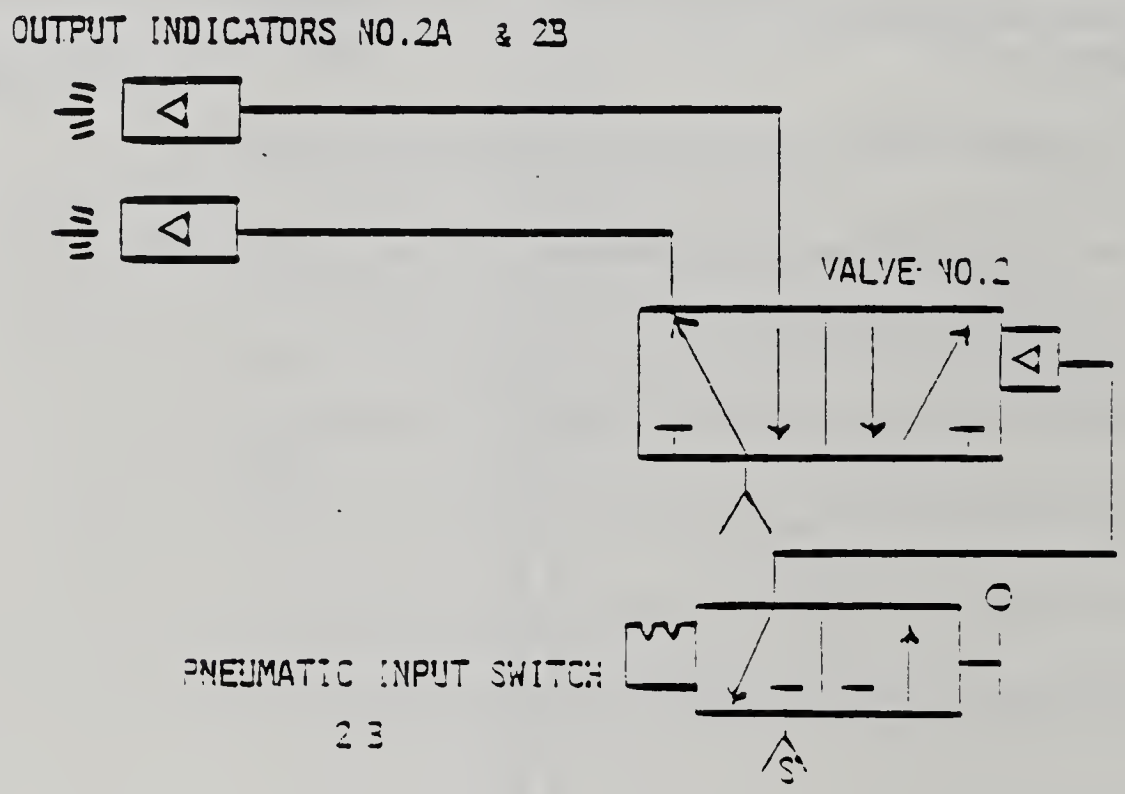


ILLUSTRATION #1

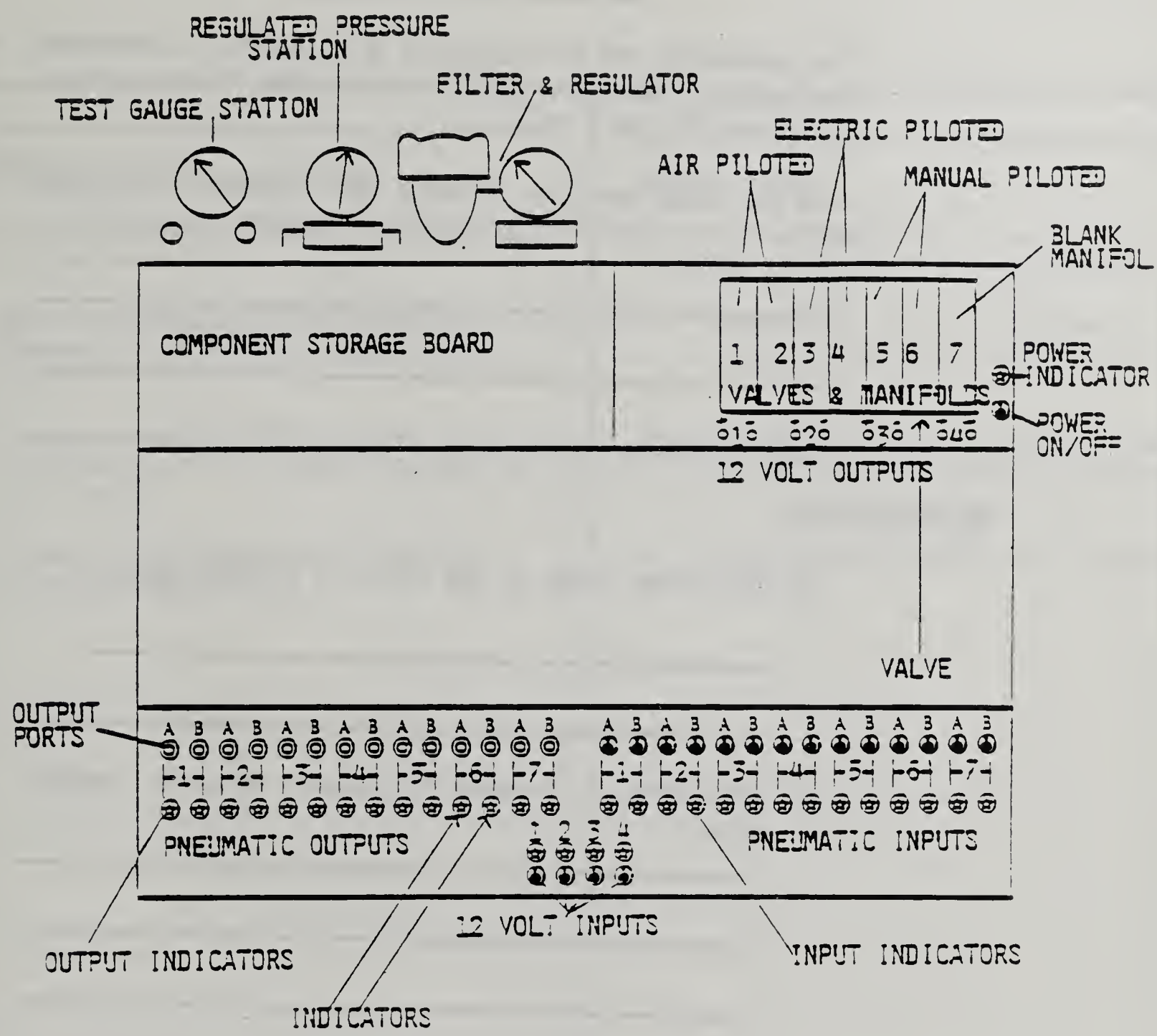


ILLUSTRATION #2

CIRCUIT TESTING PROCEDURE

✓ ☐ 1 - The components for this activity are internally connected. ie the outputs from valve NO. 6 are connected to the output indicators NO. 6A & 6B.

☐ 2 - Move the lever operator of valve NO. 6 forward; then back again. How do the output indicators respond to actuation of the valve?

_____

_____

_____

OBSERVATION:

- What takes place as the valve is shifted manually?

_____

_____

- List three (3) reasons for using a manually operated valve.

1. _____

2. _____

3. _____

INTERMEDIATE OBJECTIVE #3

Connect electric piloted valves.

LEARNING STEPS (Activities)

1. Review Student Learning Guide cited in Reference #1.
2. Read Information Sheet cited in Resource #1 to learn about electric valves.
3. Complete the circuit testing cited in Resource #2 to assure mastery of the circuit.
4. Proceed to Intermediate Objective cited in Resource #3.

RESOURCES

1. Student Learning Guide #212 is available from your instructor.
2. Information Sheet #3 begins on page 12 and is entitled "Electric Valves
3. Procudure Sheet #3 begins on page 14 and is entitled "Electric Valves."
4. Intermediate Objective #4 begins on page 15.

- SUBJECT: PNEUMATIC VALVES
- OBJECTIVE: To operate a pneumatic valve using electrical input signals
- MATERIALS NEEDED: 1 - BRAT500 PNEUMATIC TRAINER
  1 - Two position electrically operated (solenoid) valve 12VAC
- PROCEDURE: Using the above listed components, set up the pneumatic circuit as shown in illunstrations 1 & 2.

OUTPUT INDICATORS NO. 3A & 3B

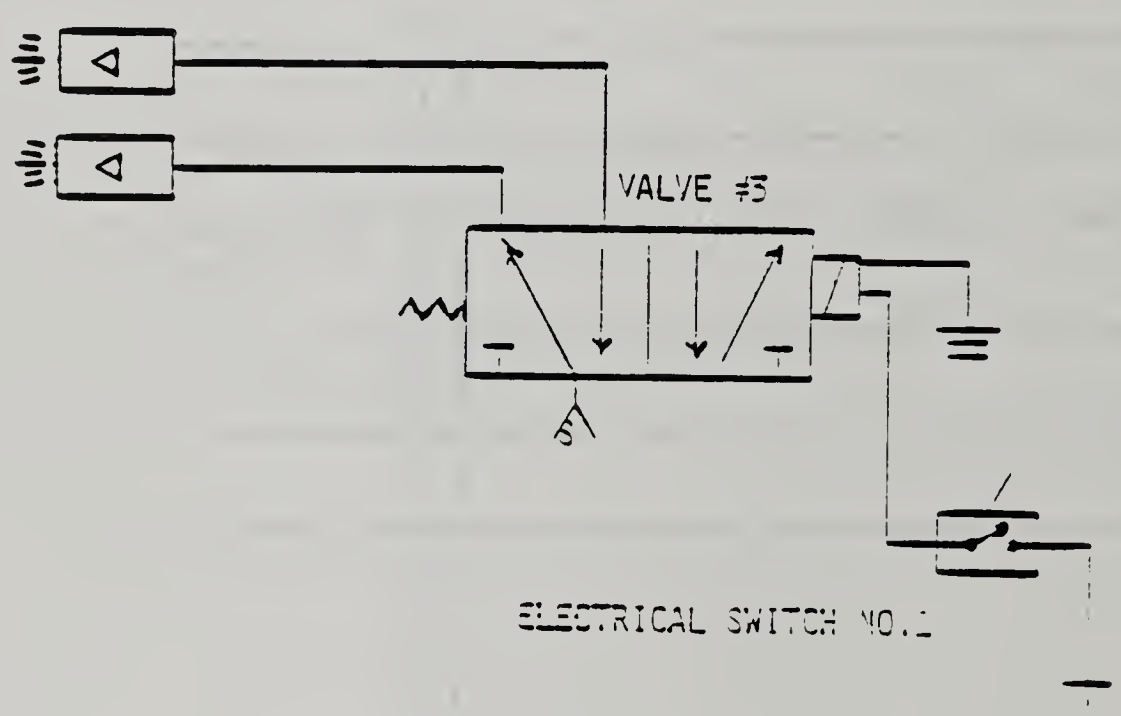


ILLUSTRATION #1

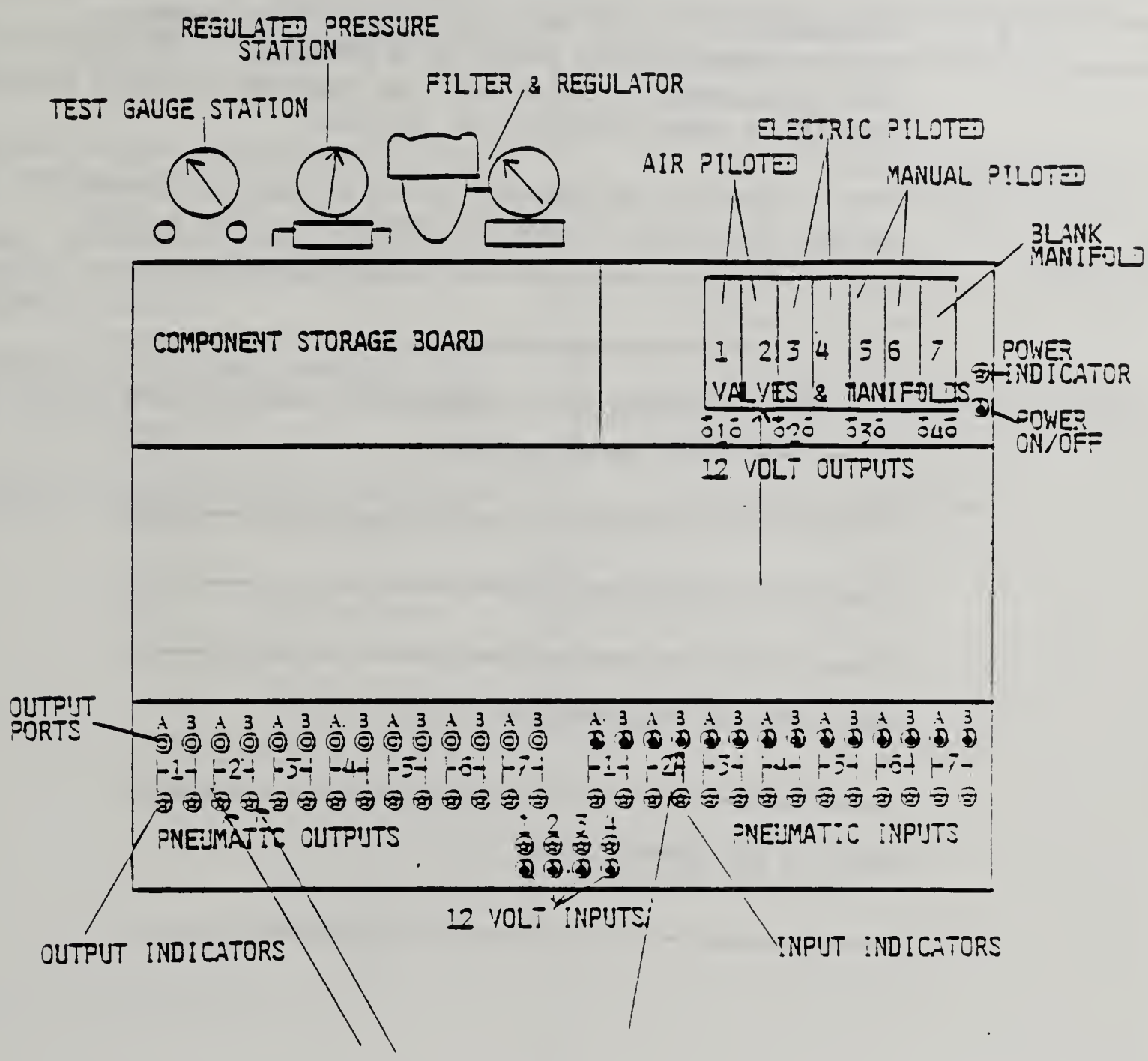


ILLUSTRATION #2

CIRCUIT TESTING PROCEDURE

✓ ☐ 1 - The components for this activity are internally connected; i.e. the pneumatic pilot switch 2B is connected to the pilot input of valve NO. 2. The outputs from valve NO. 2 are connected to output indicator NO. 2A & 2B.

☐ 1 - Move the lever on the pneumatic switch 2B back and forward. How does the indicator respond to actuation of the switch?

_____

_____

List four (4) reasons for a pneumatically piloted valve.

1. _____

2. _____

3. _____

4. _____

Which valve is considered the "SLAVE" valve?

_____

Which is the control valve?

_____

INTERMEDIATE OBJECTIVE

Connect quick exhaust valves

LEARNING STEPS (Activities)

1. Review Student Learning Guide cited in Resource #1.
2. Read Information Sheet cited in Resource #1 to learn about quick exhaust valves.
3. Complete the circuit testing cited in Resource #2 to assure mastery of the subject.
4. Complete the performance checklist for this terminal objective.

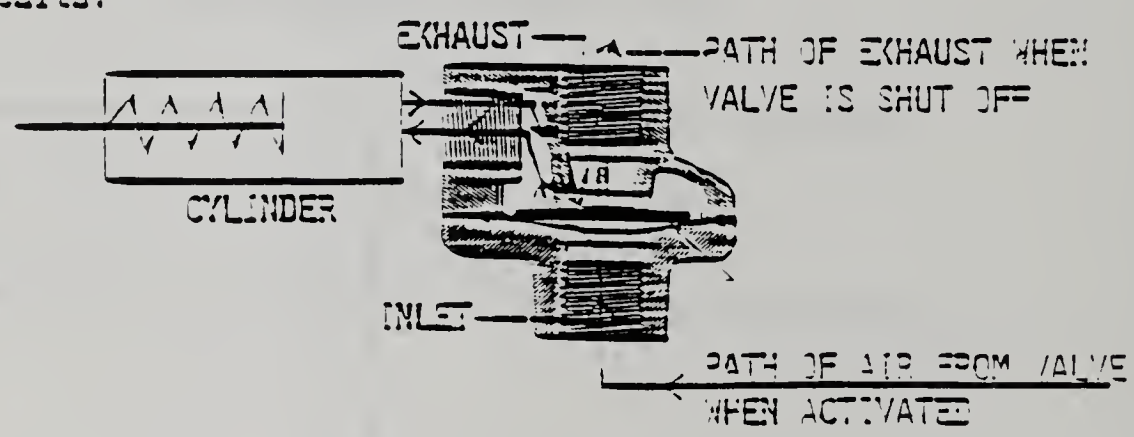
RESOURCES

1. Student Learning Guide 212 is Available from your instructor.
2. Information Sheet #4 begins on page 16 and is entitled "Quick Exhaust Valves".
3. Procedure #4 begins on page 17 and is entitles "Quick Exhaust Valves".
4. See your instructor.

- SUBJECT: QUICK EXHAUST VALVES
- OBJECTIVE: To understand the operation and location of a quick exhaust valve within a pneumatic circuit.
- MATERIALS NEEDED:
  1 - BRAT500 PNEUMATIC TRAINER
  1 - Quick exhaust valve
  1 - Single acting, spring return cylinder
  1 - 3 way manual valve (#5)
  1 - Air line with fast disconnect
  1 - Air line
  1 - Pneumatic output (#5A)

Quick exhaust valves are used with air cylinders, rotary actuators, etc., to increase the speed of the component retraction by exhausting them directly into the atmosphere instead of through a long line back to the control valve. The quick exhaust of the air allows the use of smaller valves and connecting air lines.

A quick exhaust should be installed as close as possible to the cylinder ports. Industrial applications are for single acting, spring return, air cylinders. Quick exhausts are <u>not</u> used in hydraulic circuits.



When the valve control is actuated, air passes through the quick exhaust valve and extends the cylinder rod. When the valve is released, air passes out to the atmosphere allowing the cylinder rod to retract by spring force.

PROCEDURE: Using the listed components, set up the pneumatic circuit as shown in Illustrations #1 & #2.

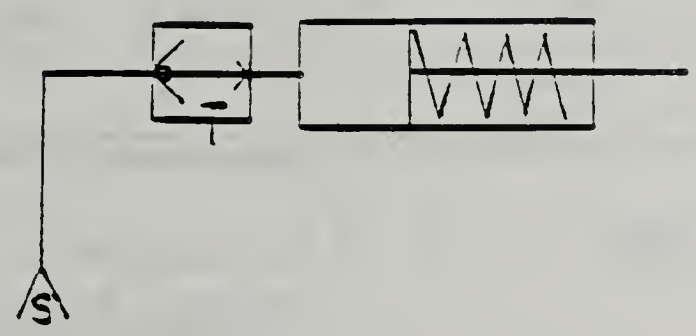


ILLUSTRATION #1

CIRCUIT TESTING PROCEDURE

✓ ☐ 1 - Attach an air line with a fast disconnect to output #5A, and the opposite end to the QUICK EXHAUST valve.

☐ 2 - Using a short air line, attach to the cylinder (Illustration #2).

☐ 3 - Activate valve #5 and hold to extend the cylinder rod.

☐ 4 - Release the valve and observe the cylinder rod retract and note the exhausted air coming from the quick exhaust valve.

☐ 5 - Re-assemble the same circuit, but this time DO NOT use the quick exhaust valve. Observe the rod speed. Repeat this activity until you observe the difference in rod speed.

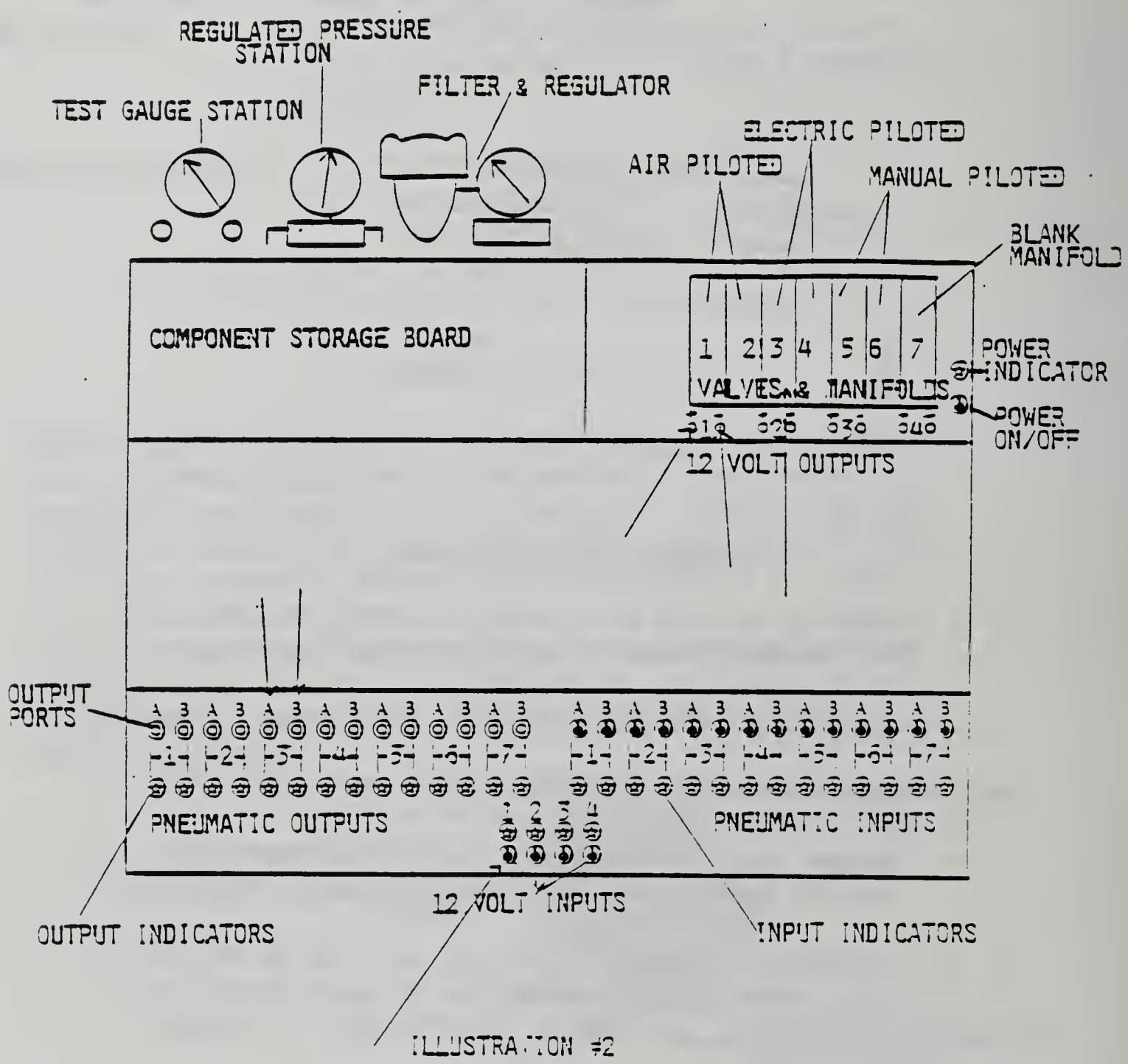


ILLUSTRATION #2

PERFORMANCE/PRODUCT CHECKLIST

Program: INDUSTRIAL ELECTRICAL MAINTENANCE

Task No: 211 DESCRIBE UNIFIED TECHNOLOGY CONCEPTS

Student's Name: _____ Date Of Attempt: _____

Evaluator's Name: _____ Evaluation Site: _____

Performance Attempt: 1 2 3 4

Terminal Performance Objective:

Given the material, design and needed tools you will connect pneumatic valves in a fluid system. You must score 100% on the performance/checklist for this objective.

Directions To The Student:

Before attempting this task for mastery, carefully review this checklist. You will be evaluated on the basis of this checklist. When you feel you are ready for evaluation, contact your instructor. You must complete your performance within ___40___ minutes and must score at least _____ out of _____ points or ___100___ % for mastery. Critical items are marked with an asterisk (*). These items must be satisfactorily completed.

Directions To The Evaluator:

The student will contact you when ready for the evaluation. The student must complete the performance within ___40___ minutes and must score _____ out of _____ points or ___100___ % and all items marked with an asterisk (*) must be satisfactorily completed.

PERFORMANCE/PRODUCT CHECKLIST

The following tasks are to be completed using the equipment and material contained in the "Brat 501" pneumatic trainer.

1. Connect one manual valve to the gripper of the robotic arm.
2. Connect one electric piloted valve to the extender of the robotic arm.
3. Connect on pneumatic piloted valve to the riser of the robotic arm.
4. Connect a quick exhaust valve to a linear plunger on the BRAT 501 table.

CRITICAL ITEMS	ITEMS TO BE OBSERVED OR CHECKED	RATING YES	RATING NO
*	1. Selected correct manual valve.		
*	2. Connected manual valve to gripper.		
*	3. Selected correct electric piloted valve.		
*	4. Connected electric piloted valve to extender.		
*	5. Selected correct pneumatic piloted valve.		
*	6. Connected pneumatic piloted valve to the riser.		
*	7. Selected correct quick exhaust valve.		
*	8. Connected quick exhaust valve to linear plunger.		
	TOTAL POINTS EARNED =		

POINTS NEEDED FOR MASTERY = 8
TOTAL POINTS POSSIBLE = 8

LAKE COUNTY AREA VOCATIONAL CENTER

COMPETENCY-BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

STUDENT LEARNING GUIDE

Produced By M. H. WHITMER Date 5/85

TASK: CONNECT FLUID SYSTEM ACTUATORS

PURPOSE: You must understand how to connect fluid system actuators into a robotic or automated system circuit. The intermediate objectives under this task presents the method of connecting actuators to help you achieve the needed understnading. The modern electrical maintenance person knows how to connect actuators into the circuit for proper operation.

INDUSTRIAL ELECTRICAL MAINTENANCE

Program	Task	Est.Time	Prereq.
17.1002	214	2 hrs.	213

edk

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME _____ SOCIAL SECURITY NUMBER _____

LENGTH OF CONTRACT (NORMAL TIME IN HOURS) _____

2. TERMINAL PERFORMANCE OBJECTIVE

Given the material and tools along with a performace checklist, you will connect fluid system actuators as requested. You must score 100% on the performance checklist for this objective.

2a. INTERMEDIATE OBJECTIVE(s)

1. Connect double acting cylinders.
2. Connect spring action return cylinders.

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____. I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

Student's Signature _____

Instructor's Signature (verifies competency) _____

INTERMEDIATE OBJECTIVE #1

Connect double acting cylinders.

LEARNING STEPS (Activities)	RESOURCES
1. Review the student Learning Guide cited in Resource #1 to recall air operated cylinder action.	1. Student Learning Guide 212 is available fromyour instructor.
2. Follow the procedure cited in Resource #2 to observe the action of a double acting cylinder.	2. Procedure Sheet #1 begins on page 4
3. Complete the testing procedure cited in Reference #3 to assure comprehension.	3. The procedure sheet #1 testing procedure begins on page 5.
4. Follow the procedure cited in Resource #4 to learn how to stop a cylinder in mid stroke.	4. Procedure sheet #2 begins on page 7.
5. Complete the testing procedure cited in Reference 5 to assure subject comprehension.	5. The procedure sheet #2 testing procedure begins on page 8.
6. Follow the procedure cited in Resource #6 to learn the actions of a three position valve and double acting cylinder.	6. Procedure sheet #3 begins on page 10.
7. Complete the circuit testing procedure cited in Resource 6 to learn the actions of a three position valve and double acting cylinder.	7. procedure sheet #3 circuit testing procedure begins on page 12.
8. Follow the procedure cited in Resource 8 to learn the action of a blocked center 3 way valve and double acting cylinder.	8. Procedure sheet #4 begins on page 14.
9. Complete the circuit testing procedure cited in Resource 9.	9. Procedure sheet #4 circuit testing procedure begin on page #15.

INTERMEDIATE OBJECTIVE #1 con't

Conntect double acting cylinders. Con't

LEARNING STEPS (Activities)	RESOURCES
10. Follow the procedure cited in resoure 10.	10. Procedure sheet #5 begins on page #16.
11. Complete the circuit testing procedure cited in resource 11.	11. Procedure sheet #5 circuit testing begins on page 18.
12. Have your instructor initial your progress to the point.	12. Signed by instructor. _____
13. Proceed to page 17.	

PROCEDURE SHEET

- **SUBJECT:** DOUBLE ACTING CYLINDERS
- **OBJECTIVE:** To observe the action of a double action cylinder
- **MATERIALS NEEDED:**
  1 - BRAT500 PNEUMATIC TRAINER
  1 - Double action cylinder
  1 - Lever, spring return, 3 position valve
  2 - Air line hoses with fast disconnects
- **PROCEDURE:** Using the above listed components, set up pneumatic circuit as shown in illustrations 1. & 2.

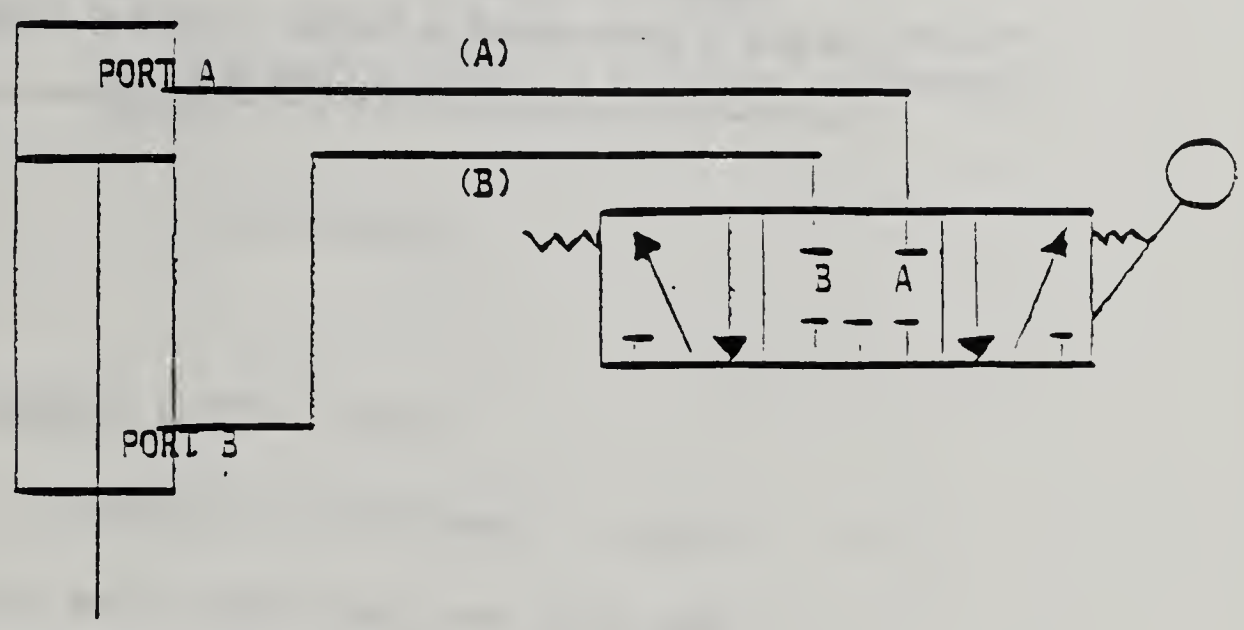


ILLUSTRATION # 1

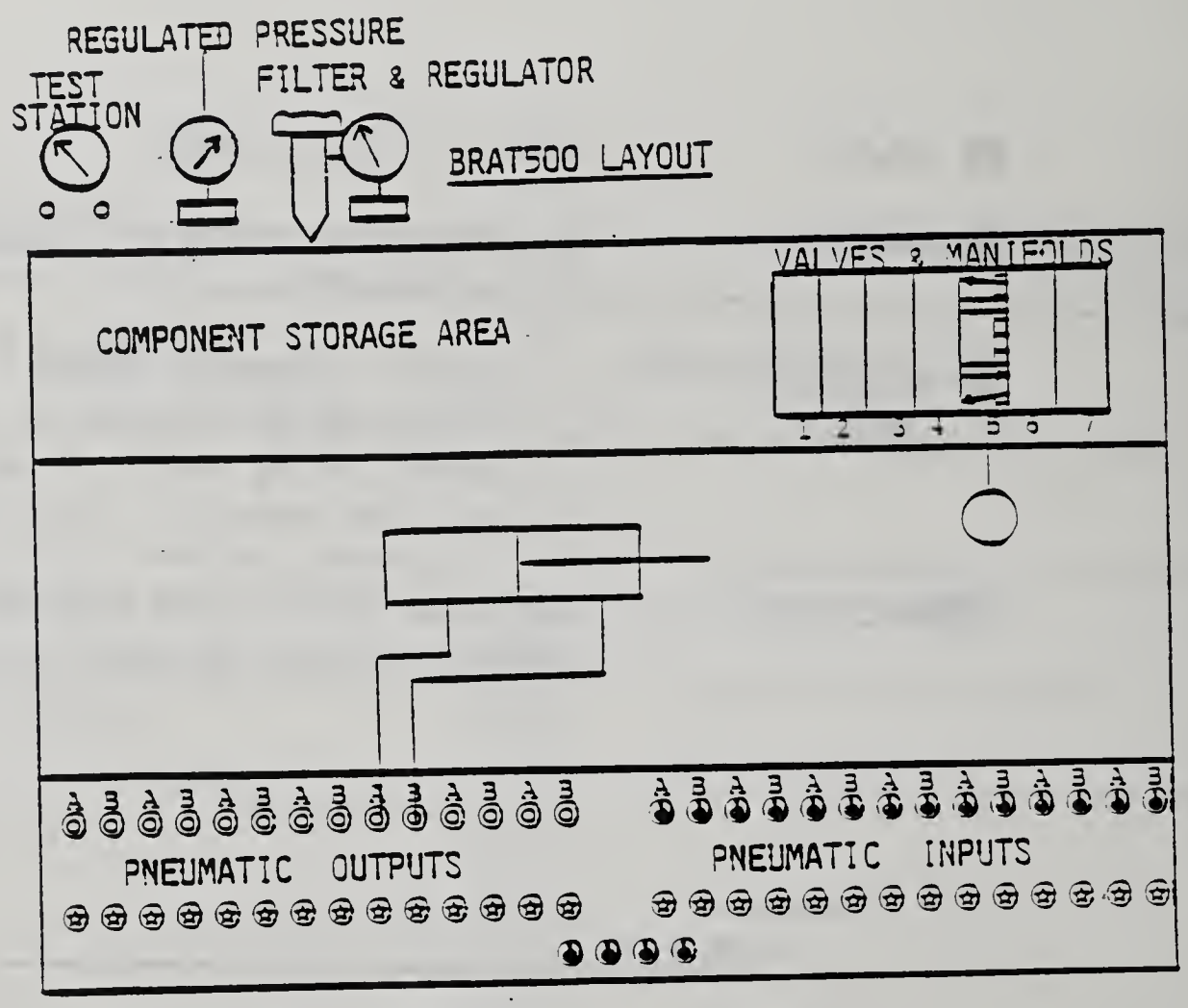


ILLUSTRATION # 2

CIRCUIT TESTING PROCEDURE

✓ = 1 - Check all connections as indicated in illustrations

= 2 - Move valve lever back. What is the reaction of the cylinder?

_____

_____

= 3 - Move the valve lever forward. What is the reaction of the cylinder? _____

_____

- 4 - Move the lever either forward or back and release it before the cylinder completes its stroke. What took place now?

  _____

  _____

- 5 - Disconnect port A from the PNEUMATIC OUTPUT connection on the trainer and follow procedures # 2 & # 3. What took place now?_____

  _____

* CONCLUSION: A double acting cylinder must have air pressure applied to both ports A & B inorder to advance or retract.

PROCEDURE SHEET

- SUBJECT: DOUBLE ACTING CYLINDERS
- OBJECTIVE: Stopping a double acting cylinder in mid stroke without any stroke creep and control the speed in both directions - metered out
- MATERIALS NEEDED:
  1 - BRAT500 PNEUMATIC TRAINER
  1 - Double acting, single ended cylinder
  1 - Pneumatic piloted valve
  1 - Pressure regulator station
  2 - Flow controls
  Air lines and disconnects
- PROCEDURE: Using the above listed components, set up the pneumatic circuit as shown in illustrations 1 & 2.

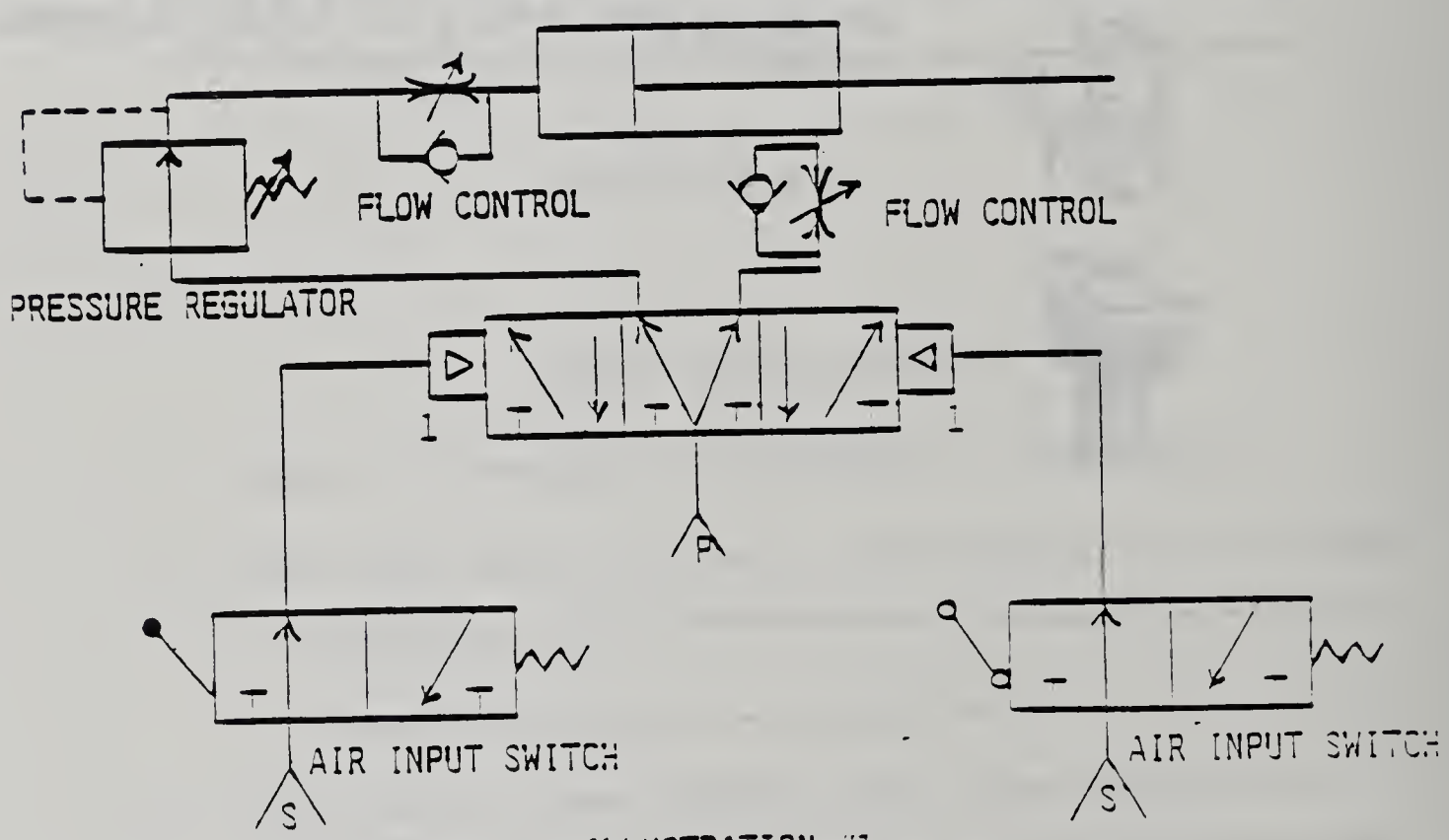


ILLUSTRATION #1

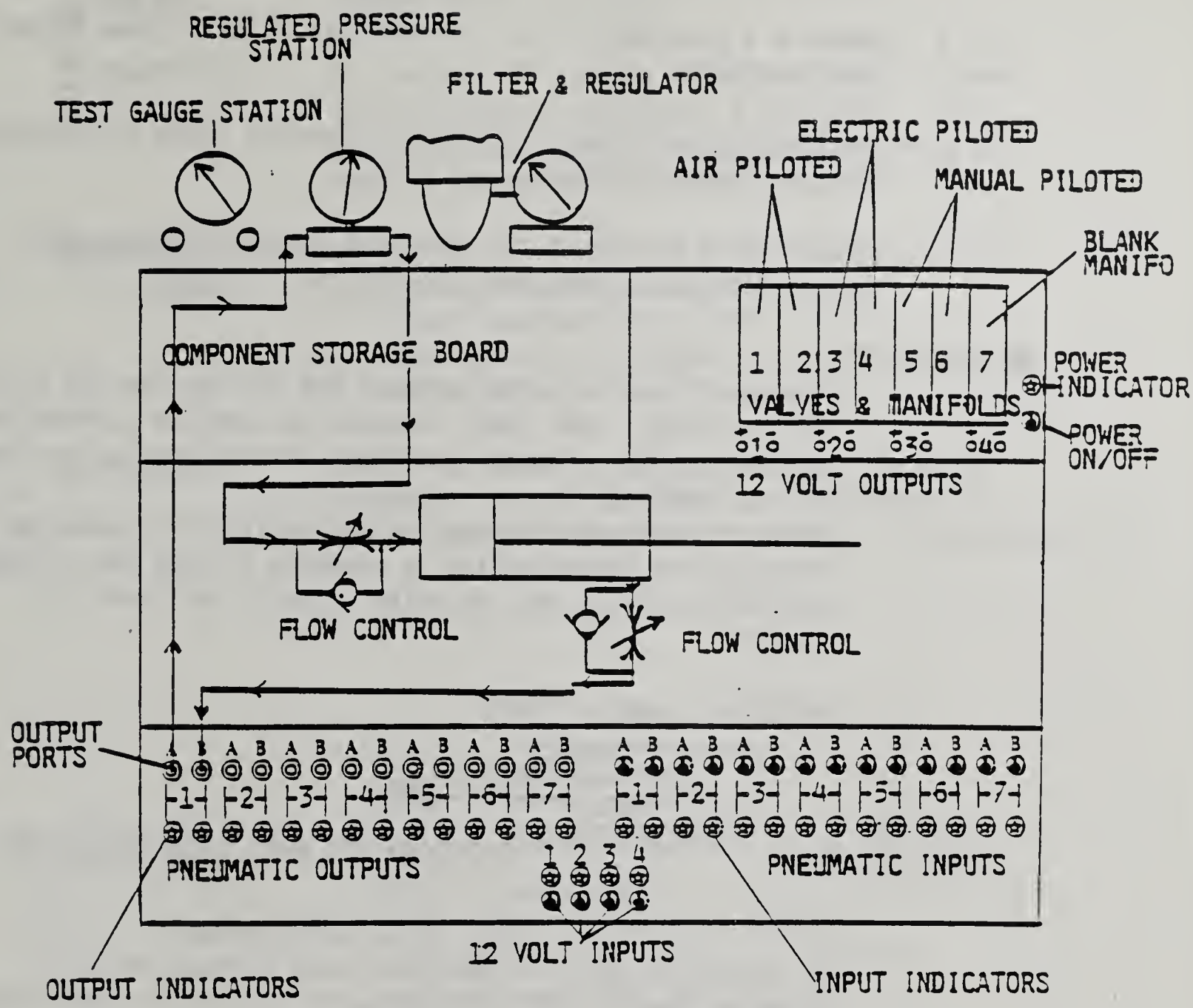


ILLUSTRATION #2

CIRCUIT TESTING PROCEDURE

✓ = 1 - Check all connections as indicated in illustrations

= 2 - Adjust regulated pressure station to main supply for equal pressure.

= 3 - Close both flow controls and open 1/2 turn

= 4 - Operate the Pneumatic input 1A. What reaction just took place?

- ☐ 5 - Close input 1A and open input 1B. What reaction took place?

  _____

- ☐ 6 - Repeat 4 & 5 adjusting the flow controls to get a slow motion back and forth.

- ☐ 7 - Use input 1B to retract cylinder and actuate input 1A stopping the cylinder mid stroke.

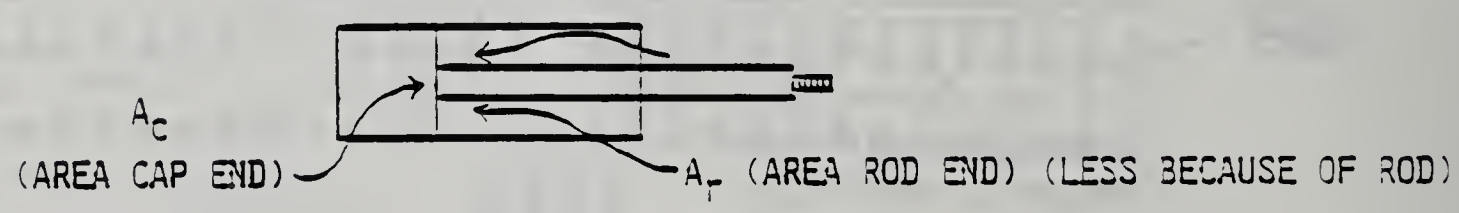
- ☐ 8 - Repeat step 7 adjusting the regulated pressure station until the cylinder stops and holds its position.

● CONCLUSION:

Because of unequal areas between the rod and the cap side of the piston, when equal pressure is supplied to both sides of the cylinder, the cylinder will advance due to less area on the rod side.

By decreasing the pressure on the opposite will equalize the force on the piston making it possible to stop the cylinder mid stroke. Using the following formula lets prove our theory!

PRESSURE x AREA = FORCE



$P_1 \times A_c = P_2 \times A_r$ (Cylinder rod in equilibrium)

To accomplish this a 3 position valve is required with pressure open to both cylinder ports. Calculate theoretical pressure on any regulator as follows;

A_c bore size of 1 1/8, area = 1.00 Sq. inches

A_r bore less 1/4" diameter rod = .75 Sq. inches

P_1 (LINE) x A_r

$80 \times .75 = 60$

$P_2 \times 1.00 = 60$

$P_2 = \frac{60}{1.00} = 60$ PSI

How does this compare with actual pressure required to stop the cylinder using the regulated pressure station?

_____

_____

PROCEDURE SHEET

SUBJECT: DOUBLE ACTING CYLINDERS

OBJECTIVE: To advance and retract a double acting cylinder using a manually operated, 3 position 4 - way valve, spring centerd, with "A" & "B" ports open to exhaust in the center position

MATERIALS NEEDED:

1 - BRAT300 PNEUMATIC TRAINER
1 - Lever operated valve (#5)
1 - Double acting cylinder
2 - Air lines with fast disconnects

PROCEDURE: Using the above listed components, set up the pneumatic circuit as shown in illustration #1 and connect the components as shown in illustration #2

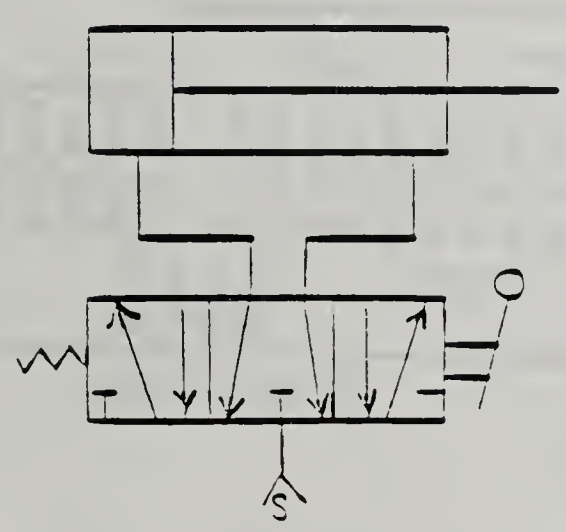


ILLUSTRATION #1

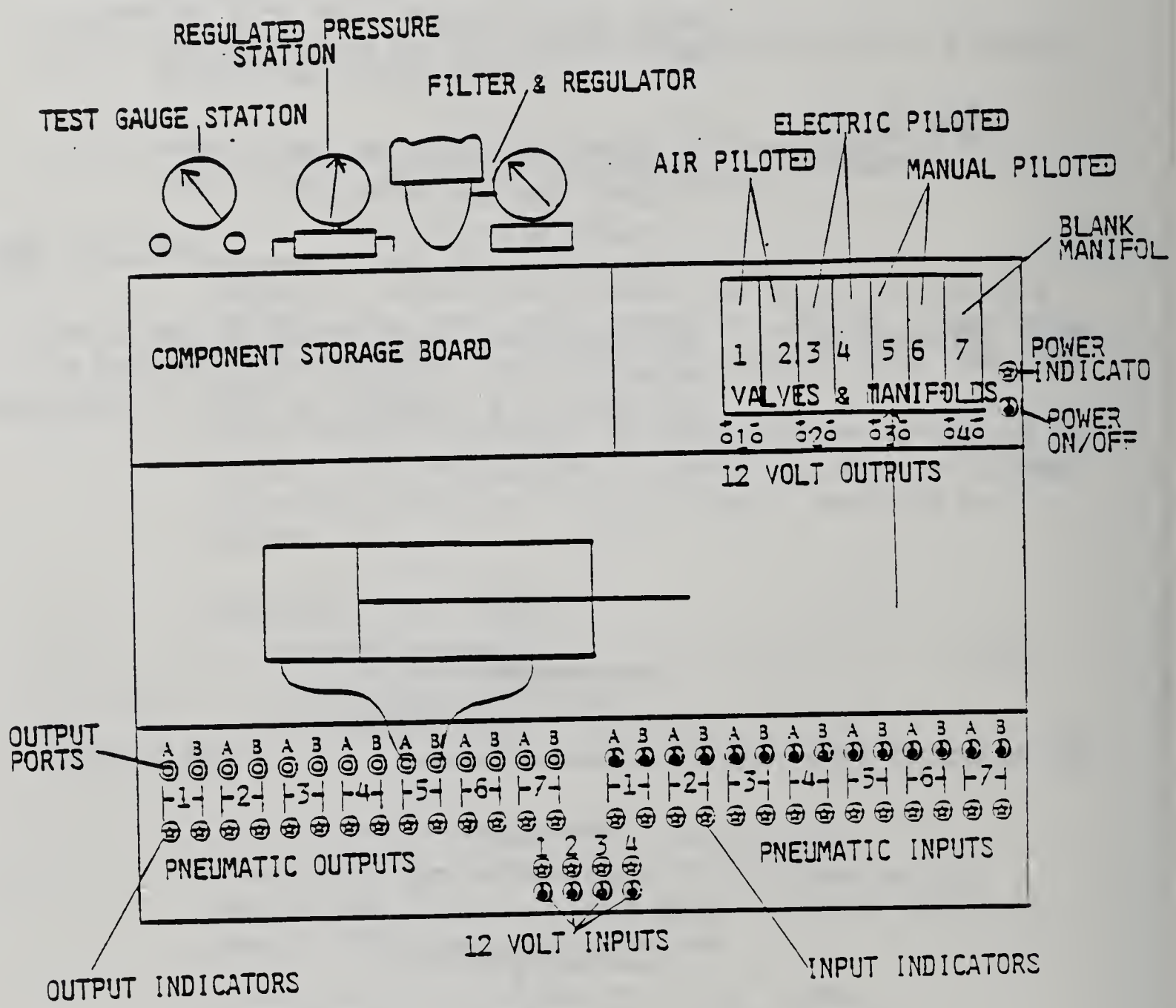


ILLUSTRATION #2

CIRCUIT TESTING PROCEDURES

✓ ☐ 1 - Advance and retract the cylinder rod by moving the valve lever forward, then backward.

☐ 2 - Now release the valve lever and try to move the cylinder rod by hand. Does it move freely?_____

● CONCLUSION:

When the valve is in the center position, the cylinder ports are open to the exhaust allowing the cylinder rod to move freely. This type of an open center valve might prove to be useful in a circuit when it may be necessary to make adjustments without disconnecting the air supply.

● NOTE: Further information available in the "ROBOTIC APPLICATIONS FOR PNEUMATICS & HYDRAULICS" chapter 6 page 12.

PROCEDURE SHEET

- **SUBJECT:** DOUBLE ACTING CYLINDERS

- **OBJECTIVE:** To advance and retract a double acting, double rod cylinder using a pneumatically piloted 4 way, 3 position valve with "A" & "B" ports blocked in the center position.

- **MATERIALS NEEDED:**
  1 - BRAT500 PNEUMATIC TRAINER
  1 - Pneumatically piloted valve #1
  1 - Double acting, double rod cylinder
  2 - Air lines with quick disconnects

- **PROCEDURE:** Using the above listed components, set up the pneumatic circuit as shown in illustration #1 and connect the components as shown in illustration #2.

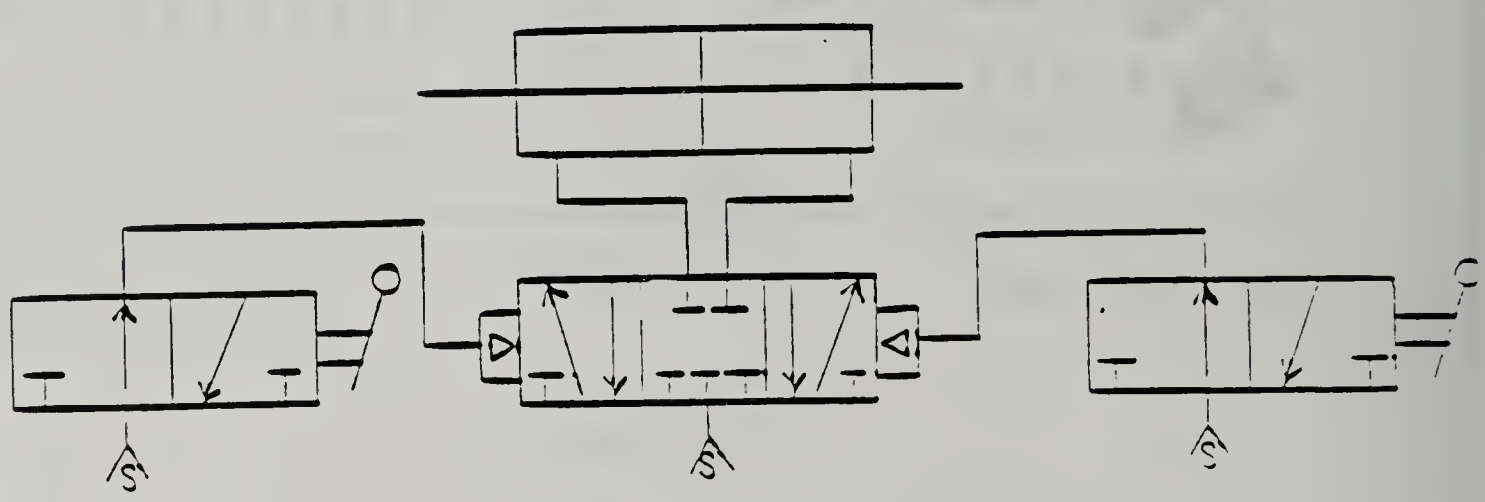


ILLUSTRATION #1

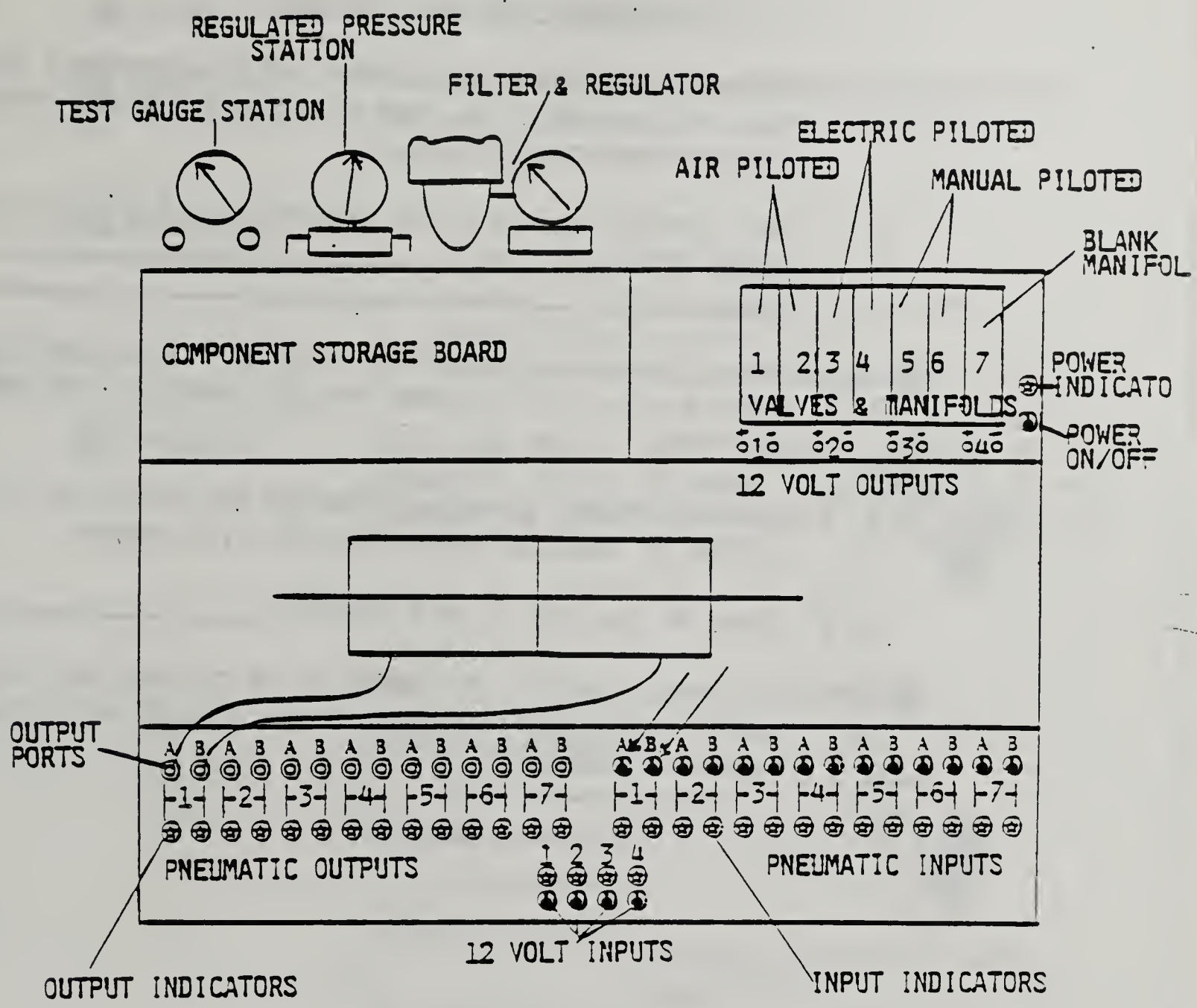


ILLUSTRATION #2

CIRCUIT TESTING PROCEDURES

✓ ☐ 1 - Advance and retract the cylinder rod by alternately moving air input switch 1A on, then off. Repeat the same procedure using air input switch 1B.

☐ 2 - What happens when 1A is not returned to the off position and 1B is turned on?_____

_____.

● NOTE: Because the valve cannot shift without first exhausting the opposite pilot, the cylinder rod will remain in the same position!

☐ 3 - Advance the rod in either direction and return the air switch to the off position before the rod fully extends.

☐ 4 - Does the rod stay in this position?_____.

● NOTE: The pressurized air is trapped in the cylinder and since a double rod cylinder has equal piston area on each side, the forces are equal.

PROCEDURE SHEET

- SUBJECT: DOUBLE ACTING CYLINDERS

- OBJECTIVE: To advance and retract a double acting cylinder using an electrically piloted, 2 position, spring return 4 way valve.

- MATERIALS NEEDED:
  1 - BRAT500 PNEUMATIC TRAINER
  1 - Electric solenoid operated valve (#4)
  1 - Double acting cylinder
  2 - Air lines with quick disconnects

- PROCEDURE: Using the above listed components, set up the pneumatic circuit as shown in illustration #1 and connect the components as shown in illustration #2.

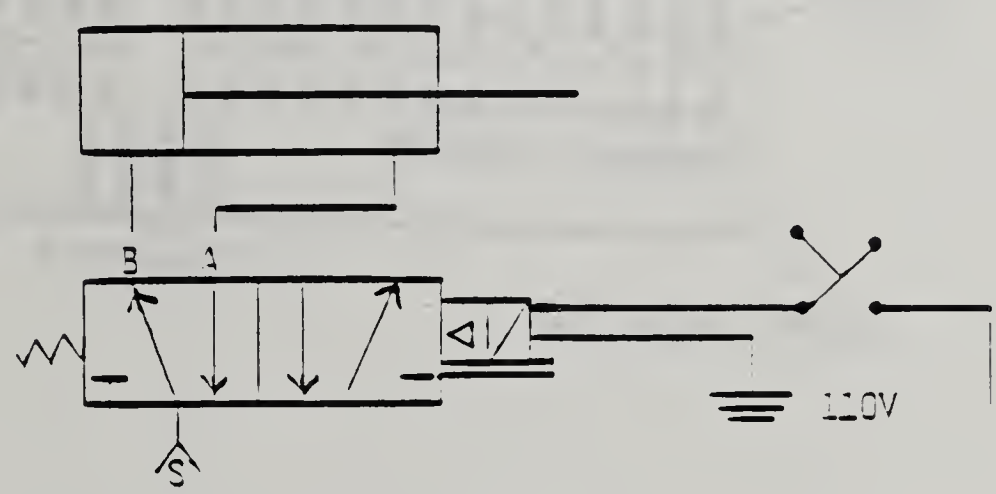


ILLUSTRATION #1

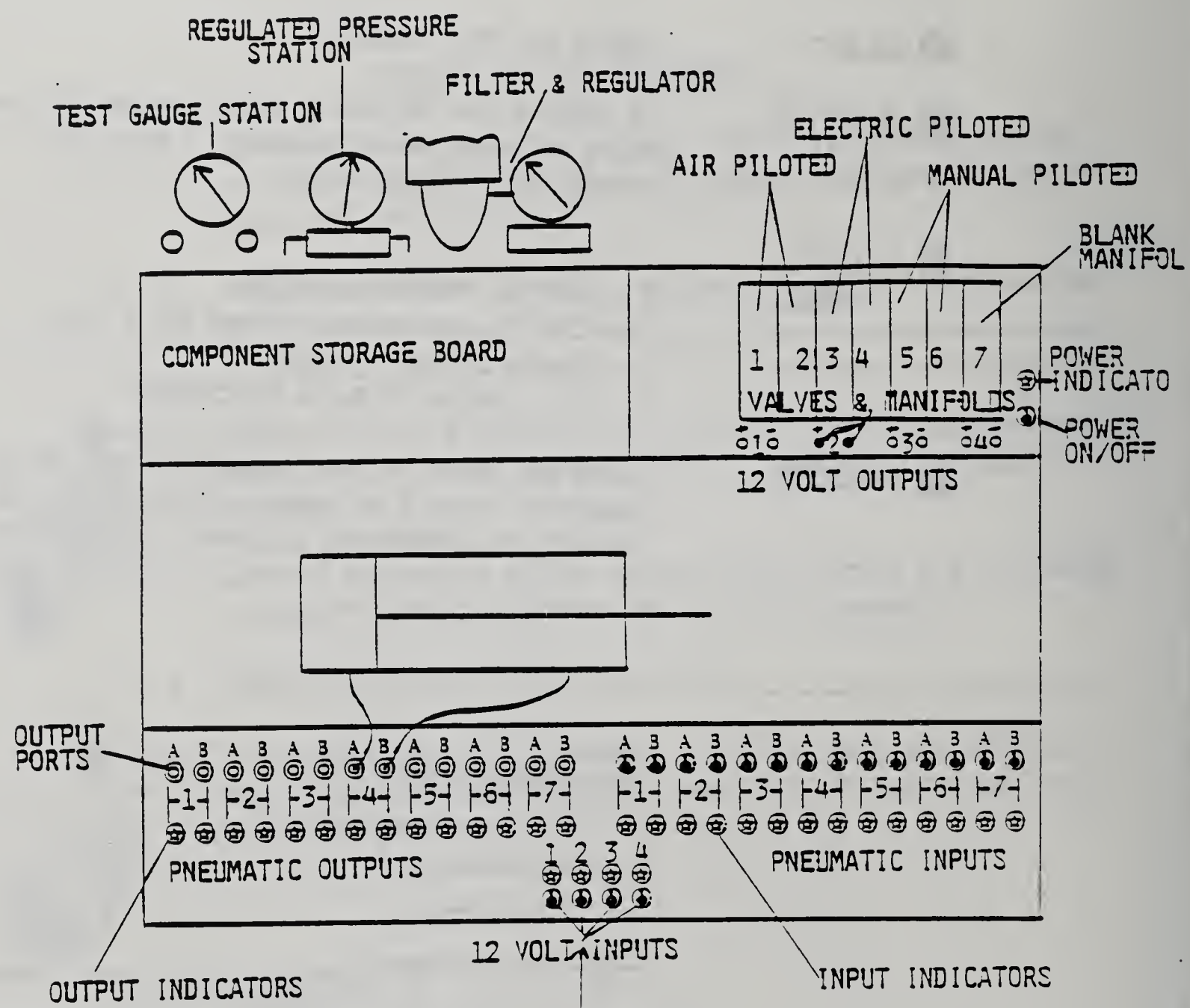


ILLUSTRATION #2

CIRCUIT TESTING PROCEDURES

✓ ☐ 1 - Advance and retract the cylinder rod by moving the electrical toggle switch #2.

☐ 2 - Why is only one switch required to move the cylinder rod in two directions?

_____

_____

☐ 3 - If the switch is returned before the cylinder fully extends, how does the cylinder respond?

_____

_____

☐ 4 - If a limit switch was used to actuate the valvr, what must be done to keep the cylinder from retracting before it fully extends?

_____

_____

_____

INTERMEDIATE OBJECTIVE #2

Connect spring action return cylinders

LEARNING STEPS (Activities)

1. Review Learning Guide in Resource #1 to recall valve and cylinder actions.
2. Follow the procedure cited in Resource 2 to learn what spring return action is.
3. Complete the circuit testing procedure cited in resource 3.
4. Complete the procedure cited in resource 4.
5. Proceed to next student Learning Guide

RESOURCES

1. Student Learning Guide 21 is available from the instructor.
2. Procedure #1 begins on page 20.
3. procedure sheet #1 circuit testing procedure begins on page 22.
4. Obtain your Performance check list from your instructor.
5. Student Learning Guide 215 is available from your instructor.

PROCEDURE SHEET

- SUBJECT: SPRING RETURN CYLINDERS
- OBJECTIVE: To advance and retract a spring return cylinder using a manually operated, two (2) position, four (4) way valve without spring return
- MATERIALS NEEDED:
  1 - BRAT500 PNEUMATIC TRAINER
  1 - Lever operated valve
  1 - Single acting spring return cylinder
  1 - Air line with quick disconnect
- PROCEDURE: Using the above listed components, set up the pneumatic circuit as shown in illustration #1 and connect the components as shown in illustration #2.

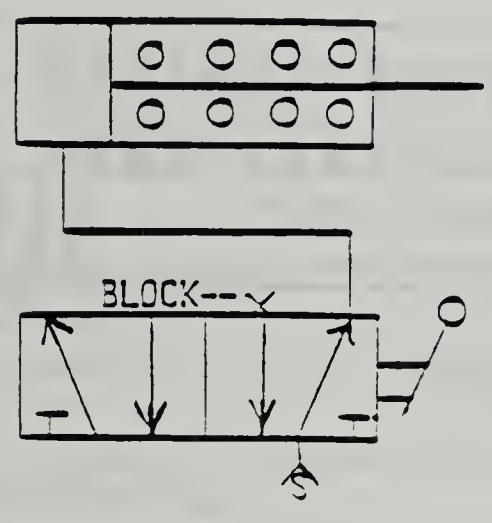


ILLUSTRATION #1

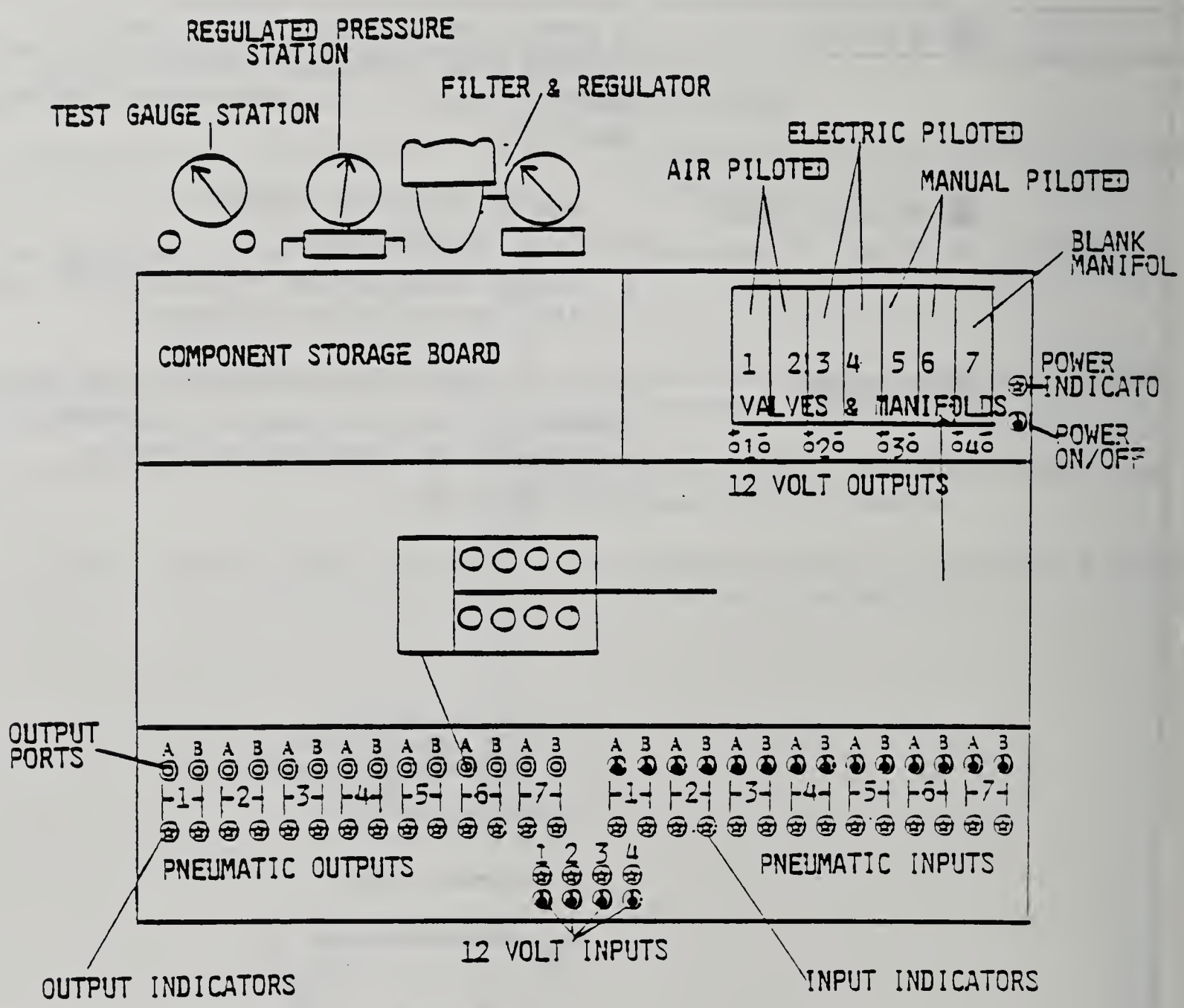


ILLUSTRATION #2

CIRCUIT TESTING PROCEDURE

✓ ☐ 1 - Advance the cylinder rod by moving the valve lever (#6) forward, then release the lever. Does the cylinder rod remain in the advanced position?_____.

WHY?_____.

☐ 2 - Retract the valve lever, what happens to the cylinder rod?

_____.

☐ 3 - What moved the cylinder rod back?

_____.

☐ 4 - The valve is a four (4) way, what happened to the output when the valve lever was retracted?

_____.

STUDENT NOTES

PERFORMANCE/PRODUCT CHECKLIST

Program: Industrial Electrical Maintenance

Task No: 214

Student's Name: _____ Date Of Attempt: _____

Evaluator's Name: _____ Evaluation Site: _____

Performance Attempt: 1 2 3 4

Terminal Performance Objective:

Given its material and tools along with a performance checklist, you will connec fluid system actuators as requested. You must score 100% on the performance checklist f this object.

Directions To The Student:

Before attempting this task for mastery, carefully review this checklist. You will be evaluated on the basis of this checklist. When you feel you are ready for evaluation, contact your instructor. You must complete your performance within 30 minutes and must score at least 10 out of 10 points or 100 % for mastery. Critical items are marked with an asterisk (*). These items must be satisfactorily completed.

Directions To The Evaluator:

The student will contact you when ready for the evaluation. The student must complete the performance within 30 minutes and must score 10 out of 10 points or 100 % and all items marked with an asterisk (*) must be satisfactorily completed.

CRITICAL ITEMS	ITEMS TO BE OBSERVED OR CHECKED	RATING	
		YES	NO
	1. Read the procedure sheet before beginning		
	2. Selected the tools and materials needed		
	3. Selected the proper valve as specified in the procedure		
	4. Connected valves to cylinders correctly		
	5. Adjusted air pressure regulator before testing circuit		
	6. Followed procedure for circuit test		
	7. Recorded data obtained		
	8. Disconnected all components safely		
	9. Returned parts to tool crib		
	10. Cleaned up work area		
	TOTAL POINTS EARNED =		

POINTS NEEDED FOR MASTERY = 100
TOTAL POINTS POSSIBLE = 100

IV

LAKE COUNTY AREA VOCATIONAL CENTER

COMPETENCY-BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

STUDENT LEARNING GUIDE

Produced By M.H. WHITMER Date 5/85

TASK: CONNECT VENTURI VACUUM GENERATOR

PURPOSE: You must understand how to connect the venturi vacuum generator into a fluid system circuit. The intermediate objectives under this task presents the method of connecting venturi vacuum generators to help you achieve the needed understanding. The modern electrical maintenance person knows how to connect venturi vacuum generators into the circuit for proper operation.

INDUSTRIAL ELECTRICAL MAINTENANCE

Program	Task	Est.Time	Prereq.
17.1002	215	2 hrs	214

edk

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME _____ SOCIAL SECURITY NUMBER _____

LENGTH OF CONTRACT (NORMAL TIME IN HOURS) _____

2. TERMINAL PERFORMANCE OBJECTIVE

Given the needed material and tools along with a performance checklist, you will connect the venturi vacuum generator. You must score 100% on the performance checklist for this objective.

2a. INTERMEDIATE OBJECTIVE(s)

1. Identify the physical parts of the venturi tube.
2. Connect the venturi vacuum generator.

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____. I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

Student's Signature _____

Instructor's Signature (verifies competency) _____

INTERMEDIATE OBJECTIVE #1

Identify the physical parts of the venturi tube.

LEARNING STEPS (Activities)

1. Read the material in the information sheet cited in Resource #1 to learn about the venturi tube.
2. Complete the self help in Resource #2 to assure subject comprehension.
3. Proceed to the next intermediate objective.

RESOURCES

1. Information Sheet #1 begins on page 4.
2. Drawing #AA is located on page 5.
3. Intermediate Objective #2 begins on page 6.

VELOCITY – PRESSURE RELATIONSHIP

Bernoulli's Law states that the higher the speed of a flowing fluid, the lower the pressure. As the speed decreases, the pressure increases, and, conversely as the speed increases, the pressure decreases. This law has numerous applications in the field of pneumatics and aeronautics. We also know that as we reduce the size of an opening the velocity increases while the pressure decreases. Devices such as pneumatic line lubricators, paint sprayers, and carburetors operate on this principle.

Venturi:

The venturi-tube can be utilized to generate pressure differences in pneumatics. This device can cause a drop in pressure as a fluid flows through it. Essentially a venturi-tube is a short straight pipe section, or throat, between two tapered sections. Local pressure varies in the vicinity of the constriction. Thus, by attaching at the throat a manometer, the drop in pressure can be measured and the flow rate calculated. It is because of this characteristic that venturi devices are commonly used as air flow meters. In fact, they are more efficient than the sharp edged orifice because of its gradual smooth restriction.

The principal advantage of the venturi tube is that not more than 10-20 percent of the difference in pressure between the inlet and the throat is permanently lost due to friction. This is accomplished by the discharge cone of the restriction which gradually decelerates the flow with minimum turbulence. The transition from the reduced area to the enlarged downstream section is also gradual and the pressure will increase to practically its original pressure on the other end of the tube.

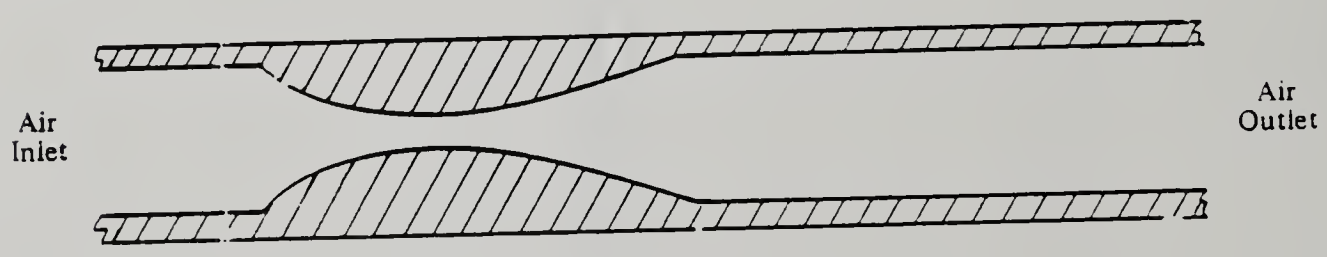
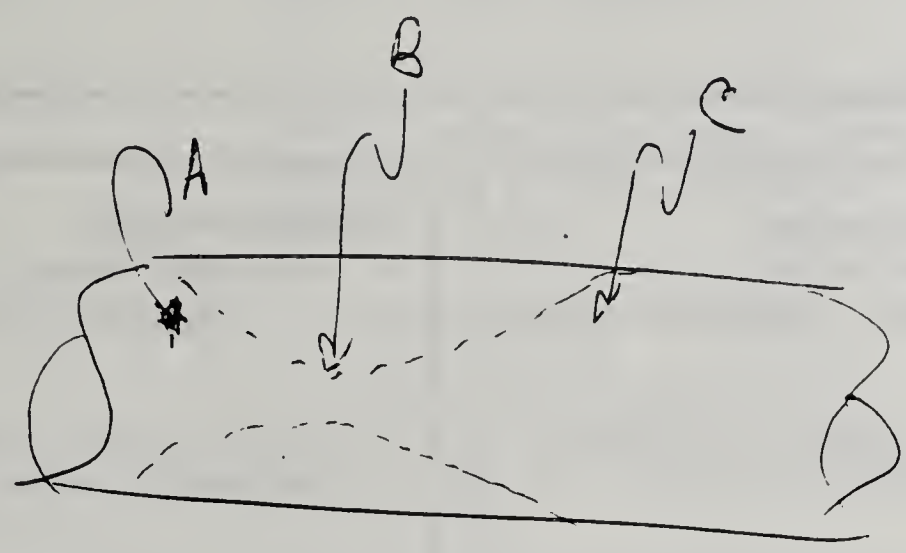


Figure A Typical Venturi – Cross Sectional View

INFORMATION SHEET #2

SELF - HELP

Identify the pressure and fluid behavior at each of the three areas, A, B, C.



A. _____

B. _____

C. _____

INTERMEDIATE OBJECTIVE #2

2. Connect the venturi vacuum generator.

LEARNING STEPS (Activities)

1. Follow the procedures cited in Resource #1 to connect a venturi vacuum.
2. Perform the circuit testing procedure cited in Resource #2.
3. Perform the evaluation project cited in Resource #3.
4. Continue to learning guide cited in Resource #4.

RESOURCES

1. Procedure Sheet #1 begins on page 7.
2. The procedure sheet #1 circuit testing procedure begins on page 8.
3. The performance checklist for this terminal performance objective begins on page 10.
4. See instructor for Student Learning Guide #216.

INFORMATION SHEET #2

SUBJECT: VENTURI VACUUM GENERATOR

OBJECTIVE: To pick up and release paper material using a venturi type vacuum generator operated by a manual, 2 position, 4 way pneumatic valve.

MATERIALS NEEDED:
1 - BRAT500 PNEUMATIC TRAINER
1 - Lever operated, 2 position, 4 way valve (#6)
1 - In-line flow control valve
1 - Air line with quick disconnect
1 - Air line

PROCEDURE: Using the above components, set up the pneumatic circuit as shown in illustration #1 and connect the components as shown in illustration #2.

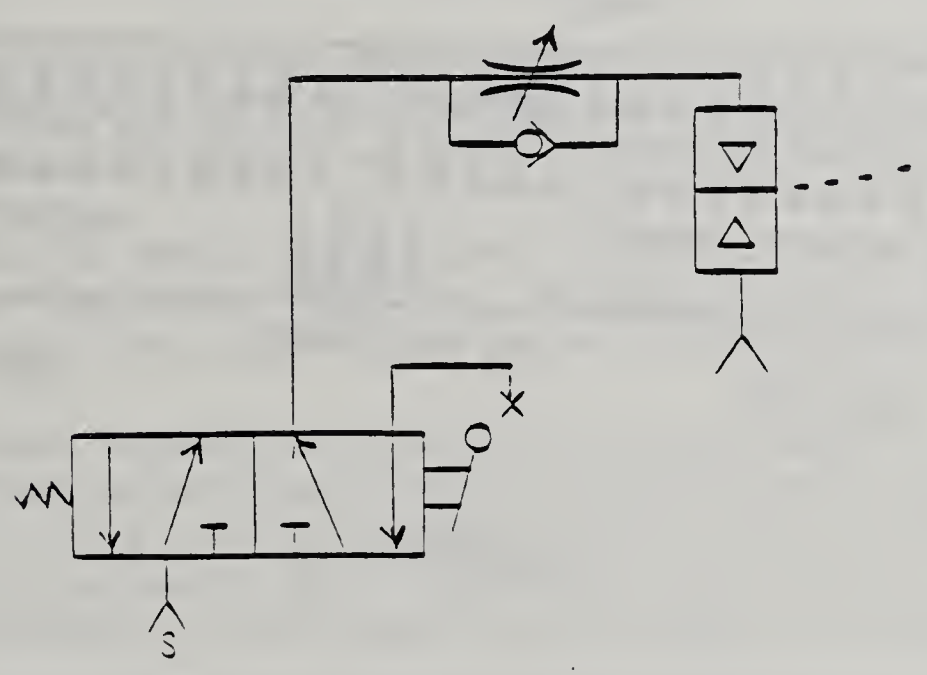


ILLUSTRATION #1

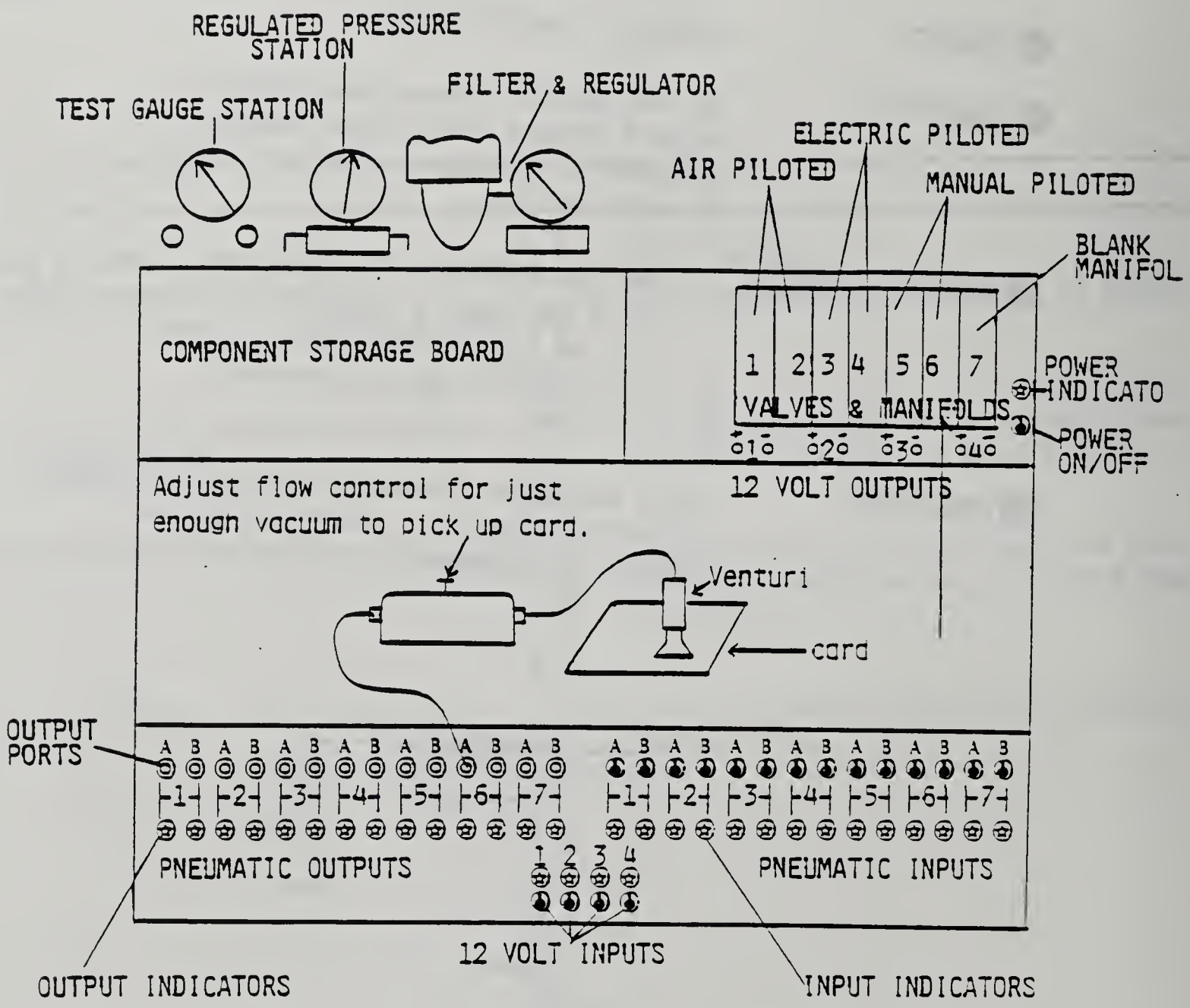


ILLUSTRATION #2

• THE VENTURI TUBE •

The venturi-tube can be used to cause pressure differences in pneumatic circuits. The venturi-tube can cause a drop in pressure as a fluid flows through it. The standard venturi is a short straight pipe section between two tapered sections as seen below in illustration #3.

BERNOULLI'S LAW states that the higher the speed of a flowing liquid, the lower the pressure. As the speed decreases, the pressure increases, and as the speed increases, the pressure decreases.

ILLUSTRATION #3

CIRCUIT TESTING PROCEDURES

✓ ☐ 1 - Valve #6 is a 4 way valve, providing an output at "A" & "B" depending on which position the lever is positioned in. During this activity we are only using one output, 6A.

☐ 2 - Hold the venturi over a piece of paper or card and adjust the flow control valve until the paper or card is drawn against the suction cup on the end of the venturi.

☐ 3 - Repeat procedure #2, but try to pick up a paper or card adjusting the pressure gauge on the air supply station at various levels, decreasing the pressure each time. Note that the venturi still reacts very positive even at low pressures. At what pressure did the venturi stop operating?

_____.

☐ 4 - We are putting pressure into the venturi, why does this result in a vacuum?_____

_____.

PERFORMANCE/PRODUCT CHECKLIST

Program: INDUSTRIAL ELECTRICAL MAINTENANCE

Task No: 215

Student's Name: _____ Date Of Attempt: _____

Evaluator's Name: _____ Evaluation Site: _____

Performance Attempt: 1 2 3 4

Terminal Performance Objective:

Given the needed materials and tools along with a performance checklist, you will connect the venturi vacuum generator. You must score 100% on the performance checklist for this objective.

Directions To The Student:

Before attempting this task for mastery, carefully review this checklist. You will be evaluated on the basis of this checklist. When you feel you are ready for evaluation, contact your instructor. You must complete your performance within 30 minutes and must score at least 5 out of 5 points or 100 % for mastery. Critical items are marked with an asterisk (*). These items must be satisfactorily completed.

Directions To The Evaluator:

The student will contact you when ready for the evaluation. The student must complete the performance within 30 minutes and must score 5 out of 5 points or 100 % and all items marked with an asterisk (*) must be satisfactorily completed.

CRITICAL ITEMS	ITLMS TO BE OBSERVED OR CHECKED	RATING YES	RATING NO
	NOTE: Student will assemble and operate a fluid system to create a vacuum with a venturi tube using 40psi supply pressure		
	1. Read the complete procedure before starting to assemble		
	2. Selected the right parts and materials for system		
	3. Adjusted pressure regulator		
	4. Connected the components correctly		
	5. Tested venturi vacuum generator for amount of lift		
	TOTAL POINTS EARNED =		

POINTS NEEDED FOR MASTERY = 5
TOTAL POINTS POSSIBLE = 5

LAKE COUNTY AREA VOCATIONAL CENTER

COMPETENCY-BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

STUDENT LEARNING GUIDE

Produced By M.H. WHITMER Date 5/85

TASK: DESCRIBE PRESSURE AND FORCE IN A FLUID SYSTEM

PURPOSE: You must understand the principles of pressure and force as they apply to robotics and automated manufacturing. The intermediate objectives under this task present the inter actions of pressure and force in the fluid system to help you achieve the needed understanding. The modern electrical maintenance person knows how pressure and force react in the fluid system to provide the energy for movement.

INDUSTRIAL ELECTRICAL MAINTENANCE

Program	Task	Est.Time	Prereq.
17.1002	216	2 hrs	215

edk

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME _____ SOCIAL SECURITY NUMBER _____

LENGTH OF CONTRACT (NORMAL TIME IN HOURS) _____

2. TERMINAL PERFORMANCE OBJECTIVE

Given a written evaluation, you will describe pressure and force as they apply to a fluid system . You must score 100% on the written test for this objective.

2a. INTERMEDIATE OBJECTIVE(s)

1. Describe the use of force in the fluid system.
2. Connect test system to measure force and pressure relationships.

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____. I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

Student's Signature _____

Instructor's Signature (verifies competency) _____

INTERMEDIATE OBJECTIVE #1

Describe the use of force in the fluid system.

LEARNING STEPS (Activities)

1. Read the information sheet cited in Resource #1 to learn about forces and pressures.

2. Complete the self-check quiz cited in Resource #2.

3. Proceed to next Intermediate Objective.

RESOURCES

1. Information Sheet #1 begins on page 4.

2. Information Sheet #1 Slef Check Quiz begins on page 13.

3. The second Intermediate Objective begins on page 15.

FLUID SYSTEMS AND PRESSURES

WHAT IS A FLUID SYSTEM?
WHAT IS PRESSURE? WHAT CAUSES PRESSURE?
HOW ARE PRESSURES MEASURED?
HOW DOES PRESSURE ACT LIKE A "FORCE" IN A FLUID SYSTEM?

Fluid systems are common in the world of technology. In general, fluid systems involve various fluids, pipes or hoses to carry the fluids, pressure devices like water pumps, and instruments here and there to measure the fluid flow rate and pressure differences. A fluid system that uses liquids is called a **hydraulic system.** A fluid system that uses gases is called a **pneumatic system.**

The fluid system we referred to earlier--water pumps, connecting hoses, engine block, radiator and water--is found in every automobile. The city water system, made up of an elevated water tank, underground pipes, water meters, house plumbing and faucets, is common in many parts of our country. Pneumatic systems involve pressurized gases in tubes, cleverly arranged to move and control key mechanical parts.

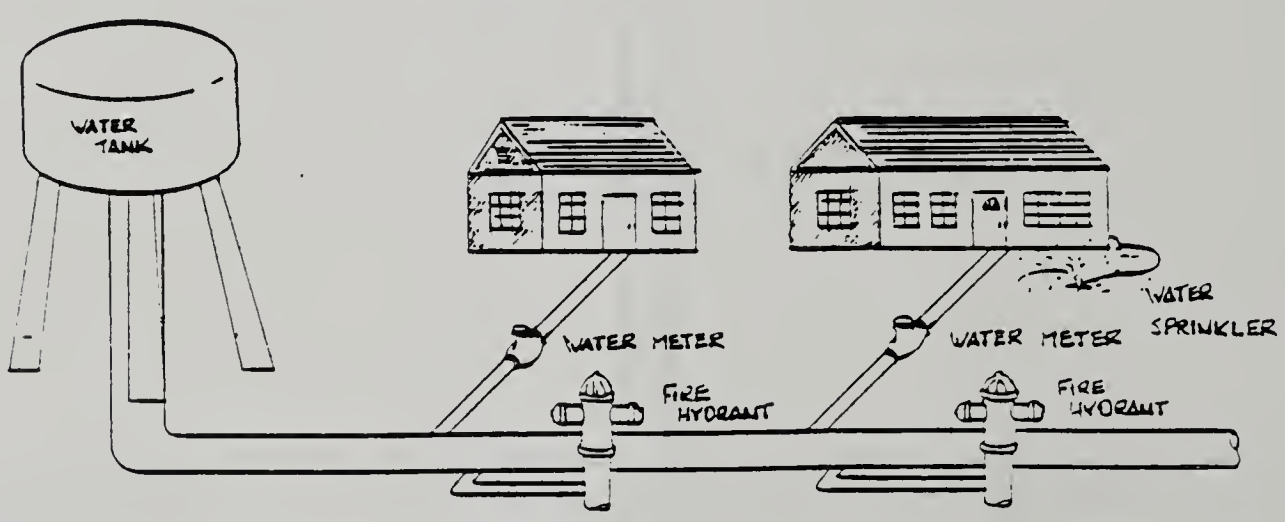


Fig. 1-20 A city water system depends on pressure to move water.

PRESSURES ACT LIKE FORCES

Whatever fluid system we examine, we find that all have several things in common. First, each system contains a fluid, either a liquid or a gas that moves through the system of connecting pipes and devices. Second, a pressure difference is generated in the system to move the fluid in a given direction and perform some special function, like opening or closing a valve. In this sense, pressure acts like a force in moving fluid through the system--in much the same way that a mechanical force (a push) moves a box, or a rotational force (a torque) tightens a bolt.

PRESSURE IS A FORCE PER UNIT AREA

Pressure is familiar to most of us. We all recognize the need for air pressure in tires. We watch lawn sprinklers barely throw out water when the water pressure is low. We hear the local weather forecaster talk about a high-pressure system moving in. It is a difference in pressure, between separated points in a fluid system, that causes fluids to move along the system--from points of high pressure to points of low pressure.

Pressure is defined as the force per unit area exerted by a fluid--liquid or gas. In the form of an equation, pressure is defined as:

$$\boxed{P = \frac{F}{A}}$$

where: F = force in newtons (N) or pounds (lb)
A = area in square meters (m^2) or square inches (in^2)
P = pressure in N/m^2 or lb/in^2

ATMOSPHERIC PRESSURE

One pressure that affects our daily lives is atmospheric pressure. Here on earth, we live at the bottom of a thick blanket of air. At sea level, the atmosphere presses down on us and everything else with a force of 14.7 pounds for every square inch of surface. At higher altitudes--like Pike's Peak--the

pressure is a little less. This "ocean" of gases--the atmosphere--is a blanket of air that extends up over us to a height of some 120,000 meters (about 75 miles). We call the force per unit area of 14.7 lb/in^2 (or 1.013×10^5 N/m^2) the **atmospheric pressure.** It acts equally in all directions and pushes with a force of 14.7 pounds on every square inch of surface--upwards, downwards, or sideways. Since pressure acts in all directions at any point in a fluid--unlike a force that acts in specific directions--it is a **scalar.** Thus pressure is completely described by specifying a magnitude--no direction is required.

ABSOLUTE AND GAGE PRESSURE

When working with fluid systems, pressure measurements are often reported as **absolute** pressure or **gage** pressure. It's important to know the difference. Let's think about filling a tire with air. We use a pump which forces more and more air (molecules of oxygen, nitrogen, helium, argon, etc.) into the tire. The tire fills up and takes on a rigid shape. If we check the air pressure with a tire gage, it might read 30 lb/in^2. What does that reading mean? Is it 30 lb/in^2 gage pressure or 30 lb/in^2 absolute pressure?

Let's try to reason it out. **Absolute** pressure is the **total** pressure measured above a reference of zero pressure--a perfect vacuum. **Gage** pressure, on the other hand is the pressure measured above atmospheric pressure. It is the total pressure minus atmospheric pressure. It is generally measured by a gage, hence the name "gage pressure."

GAGE PRESSURE = TOTAL PRESSURE - ATMOSPHERIC PRESSURE

So the tire gage reading of 30 lb/in^2 is a **gage pressure!** It means that the total pressure is really 30 lb/in^2 + 14.7 lb/in^2 or 44.7 lb/in^2. Inside the tire then, whether against the walls or treads, the trapped air pushes outwards on each square inch of tire surface with a force of 44.7 lb. But on the outside of the tire, the atmosphere pushes inward on each square inch of tire surface with a force of 14.7 lb. There is, then, a net outward push on

each square inch of tire surface of 30 lb/in^2. The tire gage measures this and records an air pressure of 30 lb/in^2.

Let's solve the following example dealing with total force pushing outward on an airplane window while the plane is at level flight high above the earth's surface. At this altitude, the pressure of the atmosphere would be considerably less than 14.7 lb/in^2. Why?

EXAMPLE 1-G: FORCE ON AN AIRPLANE WINDOW.	
Given:	An airplane window with surface area of 2 square feet. Air pressure inside the cabin is 8 pounds per square inch greater than the air pressure outside the window. Assume that cabin is pressurized so that air pressure is maintained at 14.7 lb/in^2--same as atmospheric pressure at sea level.
Find:	(a) The net force on the window. (b) Air pressure outside the plane.
Solution:	(a) $p = \frac{F}{A}$ $F = PA$ $F = (8 \frac{lb}{in^2})(288\ in^2)$ $\quad 1\ ft^2 = 144\ in^2$ Force = 2304 lb pushing outward on the window. The window must withstand a net force of 2304 lb. (b) $P_{outside} = 14.7\ lb/in^2 - 8\ lb/in^2 = 6.7\ lb/in^2$ The pressure outside is less because the plane is at a high altitude--and only part of the 75 mile thick blanket of air (the atmosphere) now exists above the plane.

PRESSURE INCREASES WITH DEPTH

In a water tank, swimming pool, or a lake, the pressure in the water increases with depth. That's not too surprising! Let's think about a water tank. The deeper the tank, the more water there is on top of each square inch of the tank bottom. This means more pounds per square inch on the bottom--or higher pressure.

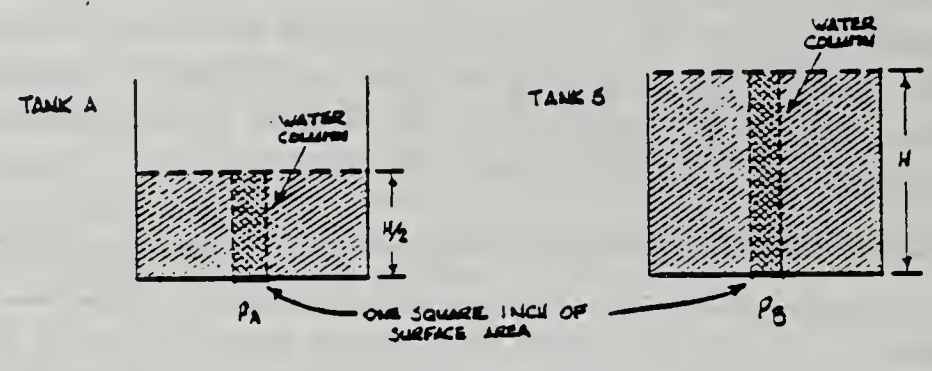


Fig. 1-21 Force per unit area on bottom of tank depends on height of water column above.

Consider two identical tanks, A and B. Tank A is half full of water, Tank B is full. Think about a square inch of surface at the bottom of Tank A and of Tank B. The column of water "sitting" on a square inch in Tank B is twice as high as that sitting on a square inch in Tank A. The column of water in B must have twice as much weight as the column in A. Since pressure is force per unit area (and weight is a force), it is clear that pressure P_B at the bottom of Tank B should be twice the pressure P_A at the bottom of Tank A. Suppose that Tank B were half as wide as Tank A, but depth of water remained H in Tank B and H/2 in Tank A, just as shown in Figure 1-21. Would P_B still be twice P_A?

We can put this all in a simple equation which tells us just how pressure in a liquid (or gas) increases with depth. The equation is:

$$\boxed{P = \rho g h}$$

where: ρ = mass density (like kg/m^3). (Here ρ is the Greek letter "rho")
g = acceleration due to gravity ($9.8\ m/s^2$)
h = liquid height (m)
P = pressure in N/m^2

In the English system of units, we usually talk about weight density (lb/ft^3) or just "density." Since we don't use mass density ($slugs/ft^3$), we can re-write the equation as:

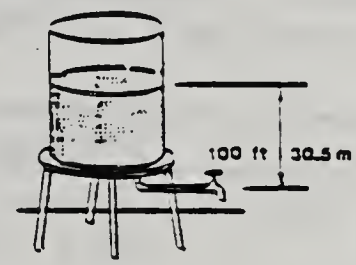
$$\boxed{P = \rho_w h}$$

where: ρ_w = weight density in lb/ft^3
h = liquid height in ft
P = pressure in lb/ft^2

Let's calculate the water pressure using both systems of units. Consider the following example.

EXAMPLE 1-H: WATER PRESSURE CALCULATION.

Given: The height of the water in a water system is 100 ft (30.5 m) above a faucet. The **mass** density of water (metric units) is 1000 kg/m^3. The **weight** density of water (English units) is 62.4 lb/ft^3.



Find: The pressure at the faucet in metric and English units.

Solution: (a) In metric units: $P = \rho g h$

$$= (1000\ kg/m^3)(9.8\ m/s^2)(30.5\ m)$$

$$P = 298{,}900\ kg/m \cdot s^2$$

But a $kg/m \cdot s^2$ is the same as N/m^2 (see note below)

$$P = 298{,}900\ N/m^2, \text{ in units of pressure.}$$

Note: $\dfrac{N}{m^2} = \dfrac{\left(\dfrac{kg \cdot m}{s^2}\right)}{m^2} = \dfrac{kg}{m \cdot s^2}$ (refer to Table 1 for help)

(b) English Units: $P = \rho_w h$

$= (62.4\ lb/ft^3)(100\ ft)$

$= 6240\ lb/ft^2$

$= (6240\ lb/ft^2)(\frac{1\ ft^2}{144\ in^2})$

$P = 43.3\ lb/in^2$

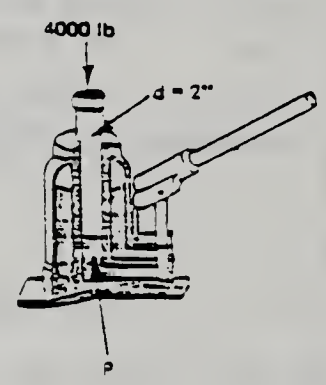
The units have been converted to the more familiar pounds per square inch. This is also force per unit area.

HYDRAULIC JACK

Pressure in an enclosed fluid pushes against all surfaces that trap the fluid. The hydraulic jack is a useful device that involves fluids to create a large lifting force on a flat surface. The automobile lift in most garages is an example of a hydraulic piston--or hydraulic jack--in action. The following example shows how pressure in a fluid, caused by pressing down on a handle to squeeze the fluid, is transmitted to a large surface area and developed into a large lifting force at that surface.

EXAMPLE 1-I: FLUID PRESSURE IN A HYDRAULIC JACK.

Given: A hydraulic jack is rated at 4000 lb lifting capacity and has a large piston with a diameter of 2 inches.



Find: Fluid pressure in the jack at maximum load.

Solution: Area: $A = \pi r^2$

$= (3.14)(1\ in)^2$

$A = 3.14\ in^2$

$P = \frac{F}{A}$

$= (4000\ lb) \div (3.14\ in^2)$

$P = 1274\ lb/in^2$

Thus, the fluid pressure throughout the inside of the jack, wherever fluid is found, is $1274\ lb/in^2$.

EQUILIBRIUM IN FLUID SYSTEMS

Motion occurs in a fluid system because pressure differences exist between different points in the system. It is for this reason that it's useful to think of pressure acting like a force in fluid systems. Let's make this point a little clearer. Figure 1-22 shows two tanks connected by a pipe containing an on-off valve. The pressure at the bottom of each tank is different because the water level in Tank 2 is higher than in Tank 1. The pressure P_1, at the bottom of Tank 1 is less than P_2, the pressure at the bottom of Tank 2. Now if the pipe between the two tanks is connected to each tank at the bottom, then the pressure on the left side of the valve is P_1 and that on the right side is P_2. Therefore, there must be a pressure difference across the valve. What happens if the valve is opened?

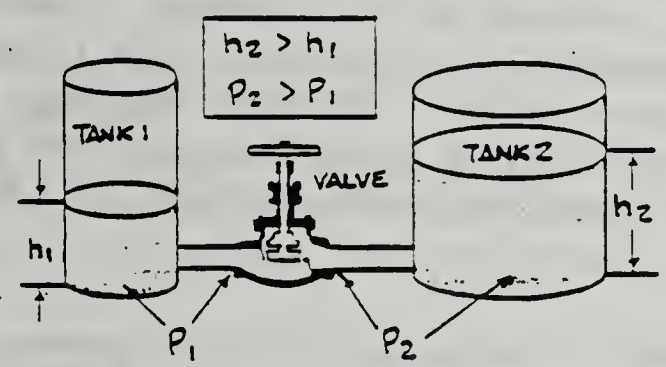


Fig. 1-22 Unbalanced pressures across valve.

Since pressure P_2 is greater than P_1, there will be a force per unit area on the right side of the valve greater than the force per unit area on the left side of the valve. Water will then flow through the valve from Tank 2 to Tank 1 until the levels in the two tanks are equal. When water depths in Tank 1 and Tank 2 are equal, P_1 and P_2 will be equal, and the system will be in equilibrium. This situation is shown in Figure 1-23.

Note that Tank 2 is larger and has more water than Tank 1. But pressure depends only on the depth. It does not depend on the shape of the container or the amount of water it holds. And since the depths are equal, the pressures are equal, quite independent of the unequal volumes of water in each tank.

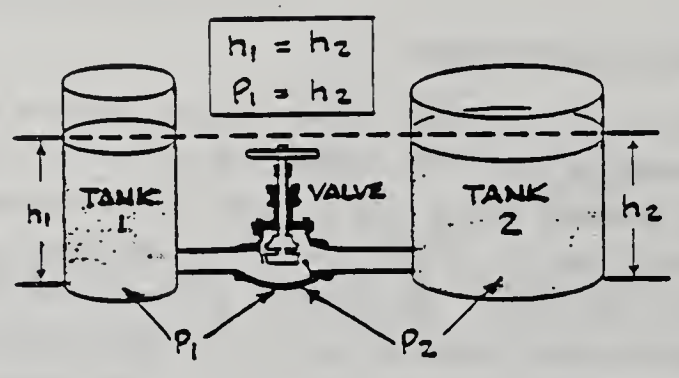


Fig. 1-23 Balanced pressures across valve.

MEASURING PRESSURES

The same principles we talked about in the illustration of the two tanks connected by a pipe are used in an instrument to measure gas pressure. This useful instrument is called a manometer. It is a U-shaped glass tube partially filled with mercury. Much heavier than water, mercury has a weight density 13.6 times that of water. Thus, since water has a weight density of 62.4 lb/ft^3, mercury has a weight density of 13.6 x 62.4 lb/ft^3 or 848.6 lb/ft^3.

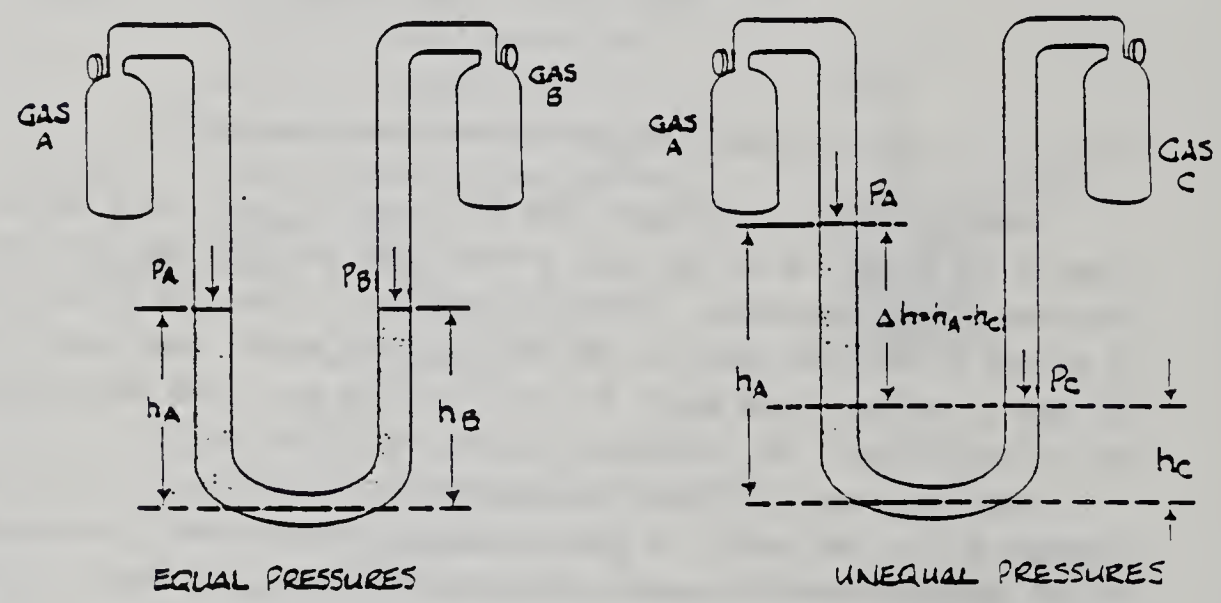


Fig. 1-24 Manometers are used to measure pressures.

In the left part of Figure 1-24, Gas A and Gas B are at the same pressure. Each exerts the same force per unit area on the two mercury columns in the U-tube. Since $P_A = P_B$, at the top of each mercury column, the mercury must be at the same level in each arm, so $h_A = h_B$. In the right part of Figure 1-24, Gas C is at a higher pressure than Gas A. It pushes down harder on the right column of mercury than does Gas A on the left column. The mercury column therefore moves down in the right arm and up in the left arm. By measuring the difference in height of the two columns of mercury in the U-tube, and using the equation $P = \rho_w h$ discussed earlier, we can calculate the difference in pressure between Gas A and Gas C. Then, if we know the pressure of Gas A, we can calculate the pressure of Gas C. We shall try this in a laboratory exercise.

SELF-CHECK

1. Think about a washing machine. Is it made up of different energy systems? Can you name them?
2. Think about the fluid system in a washing machine. What are the parts? What causes the pressure that forces the water around?
3. Define **pressure** in your own words. What units are used to measure pressure?
4. Some bicycle tires are filled with air until the tire gage reads 55 lb/in^2.
   a. What is the gage pressure?
   b. What is the absolute pressure inside of the tire? (Assume a normal atmospheric pressure of 14.7 lb/in^2.)
   c. What is the absolute pressure outside of the tire?
   d. What is the net force on each square inch of the tire wall? Which direction does this force act?
5. Two cylindrical glass beakers of the same height are filled with water. One beaker has four times the diameter of the other, so it holds much more water.
   a. How do the pressures at the bottom of each beaker compare?
   b. Which beaker has the larger force pressing down on its bottom?
6. How much does one cubic foot of water weigh in pounds? in newtons?

INFORMATION SHEET

7. What is the mass of one cubic centimeter of water in grams?
8. The height of the water level in a city water system is 150 feet above a faucet.
   a. What is the water pressure at the faucet in lb/in^2?
   b. What is the water pressure at the faucet in N/m^2?
9. How does a hydraulic jack develop large forces to lift heavy objects? Explain carefully. Use a rough drawing to help show your ideas.
10. Pressure depends on height, as we have learned. Because of this, one often gives the atmospheric pressure reading in terms like "750 mm Hg." What does this mean? How can a height of mercury in a tube be converted to real pressure units in N/m^2--or in lb/in^2?

INTERMEDIATE OBJECTIVE #2

Connect test system to measure force and pressure relationships.

LEARNING STEPS (Activities)	RESOURCES
1. Refer to information sheets cited in Resource #1 for review of force in fluid systems.	1. Information Sheet #1 begins on page 4.
2. Perform the activities cited in Resource #2 to learn how pressure and force are related.	2. Procedure Sheet #1 begins on page 16.
3. Complete the test circuit procedure cited in Resource #3 to assure subject comprehension.	3. Procedure Sheet #1 test circuit procedure begins on page 18.
4. Complete the evaluation for this terminal objective.	4. See your instructor for the evaluation instrument for this Intermedicate Objective.
5. Proceed to the learning guide cited in Resource #5.	5. See instructor for student learning guide 217.

PROCEDURE SHEET

- SUBJECT: PRESSURE & FORCE ACTIVITY

- OBJECTIVE: To advance and retract a double acting cylinder with 50 lbs. of force and retract with full line pressure with speed control

- MATERIALS NEEDED:
  1 - BRAT500 PNEUMATIC TRAINER
  1 - Single air piloted valve
  1 - Pneumatic input switch
  1 - Double Acting Cylinder
  1 - Pressure regulator
  1 - Flow control valve
  3 - Air line hoses with fast disconnects

- PROCEDURE: Using the above listed components, set up the pneumatic circuit as shown in illustrations 1 & 2.

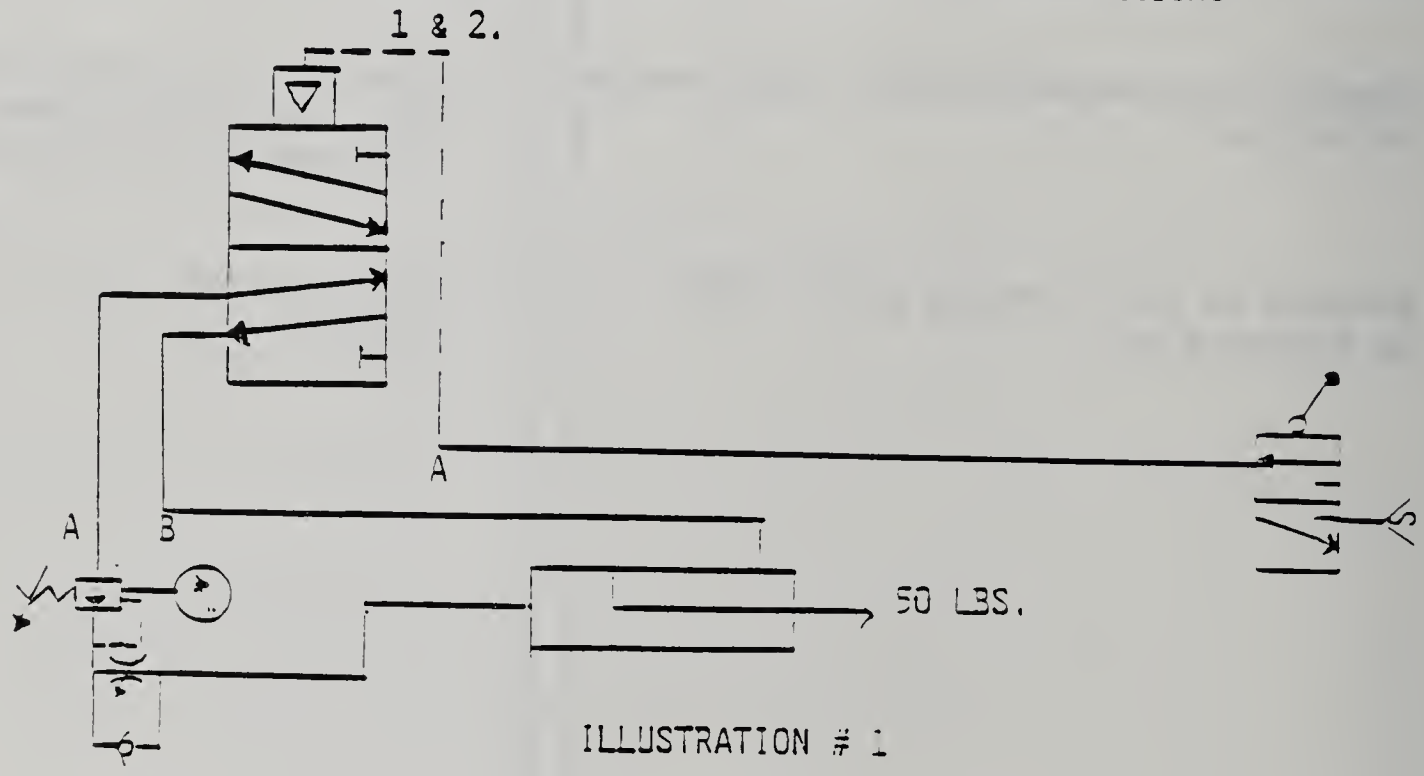


ILLUSTRATION # 1

FORMULA

FORCE (F) = PRESSURE (P) X AREA OF CYLINDER (A)

FORCE REQUIRED = 50 LBS.

$$P = \frac{F}{A}$$

$$P = \frac{50}{A}$$

A = 1.228 sq. inch for 1 1/4" Bore

$$P = \frac{50}{1.228} = 41 \text{ PSI (SET REGULATOR)}$$

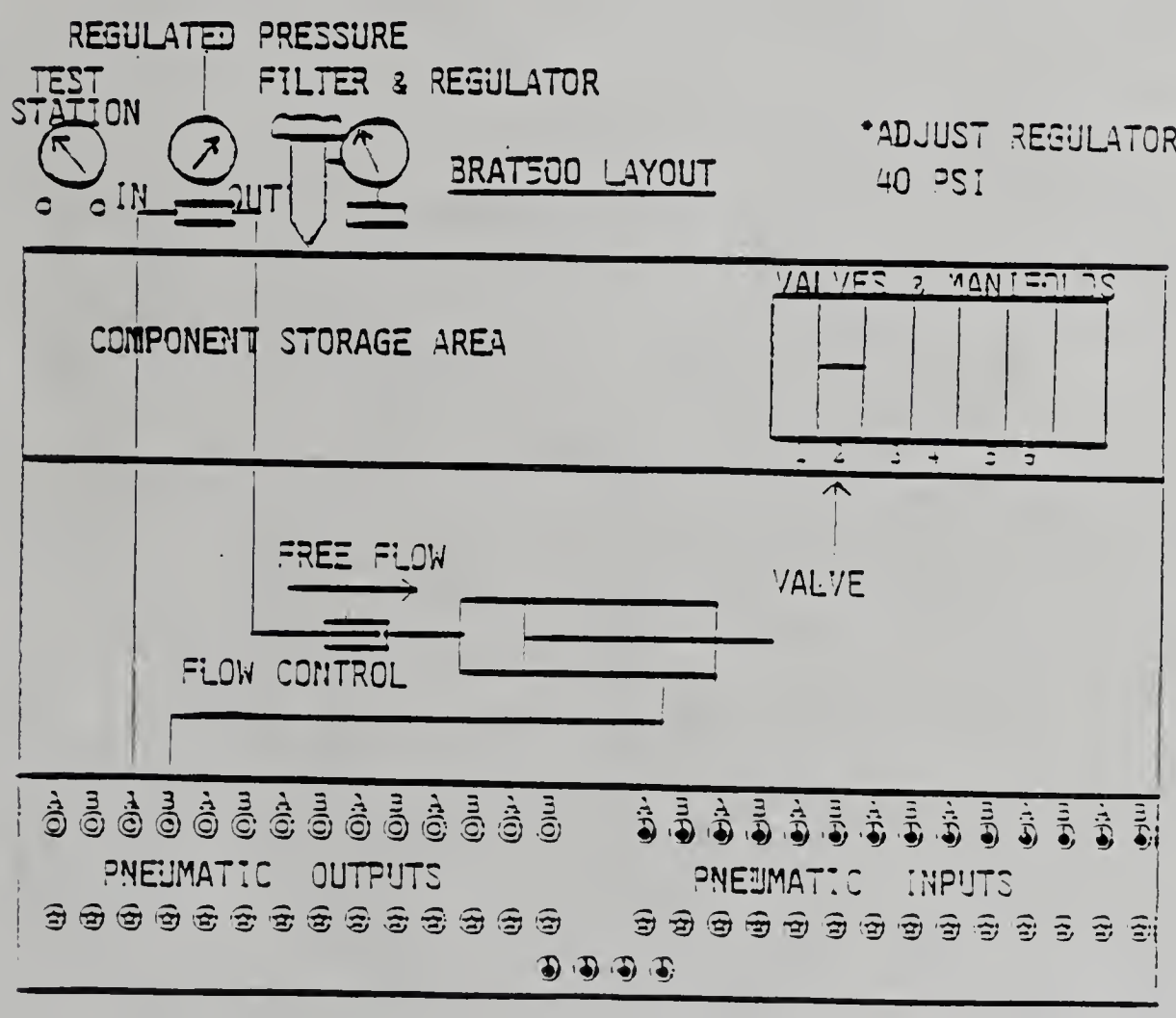


ILLUSTRATION # 2

TEST CIRCUIT PROCEDURE

✓☐ 1 - Check all connections as indicated in illustrations

☐ 2 - Adjust pressure with regulator to approx. 41 PSI on gauge

☐ 3 - Close flow control valve, then open 1/2 turn

☐ 4 - Activate air input switch; cylinder should move forward with 50 lbs. of force at full speed

☐ 5 - Deactivate air input switch, cylinder should retract slowly

☐ 6 - Adjust flow control for various speed observations

★ FORMULA PROBLEM ★

☐ 1 - Using the formula on the preceeding page, change the force required to 25 LBS and recalculate the formula below and reset the pressure regulator and follow the test circuit procedures with the new calculations.

FORCE REQUIRED = 25 LBS.

P = ——

P = —— .

A =

P = —— = PSI

PROGRAM INDUSTRIAL ELECTRICAL MAINENANCE

CRITERION EXAM

TASK = 216

DIRECTIONS:

THE PURPOSE OF THIS EXAM IS TO DETERMINE WHETHER OR NOT YOU HAVE UNDERSTOOD THE INFORMATION ON PRESSURE AND FORCE AS THEY APPLY TO A FLUID SYSTEM.

Each of the questions or incomplete statements below is followed by several words, phrases, or a series of numbers. Choose the one which best answers the question or completes the statement correctly. Place the letter associated with that choice (A,B,C or D) in the numbered blank space on your ANSWER SHEET. DO NOT WRITE ON THIS TEST!!! To master this exam you must answer 10 out of 10 items correctly, 100 %.

EVALUATION SHEET

Complete the following questions.

1. What are the units for fluid pressure?_____

2. What is relative pressure?_____

3. What is absolute pressure?_____

4. Atmospheric pressure is a constant value_____

5. How does a hydraulic jack develop large forces to raise heavy objects?

6. How does a pressure regulator reduce pressure?_____

7. A flow control valve reduces flow by_____

8. Write the formula for calcutating pressure, force and area.

9.&10. How much does one cubic foot of water weigh in pounds?_____
In newtons?_____.

Illinois State Board of Education

Department of Adult, Vocational and Technical Education
Research and Development Section

Product Abstract

1. Title of material Industrial Electrical Maintenance Task Listing by Occupational Titles

2. Date material was completed FY85

3. Please check one: New material X Revised material ____ Field-tested material ____

4. Originating agency Lake County Area Vocational Center

   Address 19525 West Washington St., Grayslake IL Zip Code 60030

5. Name(s) of developer(s) Melvin Whitmer

   Address Lake County Area Vocational Center Zip Code ____

6. Developed pursuant to Contract Number R-99-25-X-0000-499

7. Subject Matter (Check only one according to Department of Education Code):

   Code

   ____ 01 Agricultural Education
   ____ 03 Business and Office Education
   ____ 04 Distributive Education
   ____ 07 Health Occupations Education
   ____ 09 Home Economics Education
   ____ 10 Industrial Arts Education
   ____ 16 Technical Education
   XX 17 Trade and Industrial Education
   ____ 22 Cooperative Education
   ____ Career Education
   ____ Other (Specify) ____

8. Education Level:

   ____ Pre-K Thru 6
   ____ 7-8
   ____ 9-10
   X 11-12
   X Post-Secondary
   X Adult
   ____ Teacher (Pre-service)
   ____ Administrator (Pre-Service)
   ____ Other (Specify) ____

9. Intended for Use By:

   X Student
   X Classroom Teacher
   X Local Administrator
   ____ Teacher Educator
   ____ Guidance Staff
   ____ State Personnel
   ____ Other (Specify) ____

10. Student Type:

    X Regular
    ____ Disadvantaged
    ____ Handicapped
    ____ Limited-English Proficiency
    ____ Other (Specify) ____

11. Medium and Format of Materials:

    X HARDCOPY
    ____ VIDEOTAPE
    ____ FILM
    ____ MICROFICHE

    No. of pages 31
    ____ Paper bound
    ____ Hard bound
    X Loose-leaf
    Photos: Yes ____ No ____
    Diagrams: Yes ____ No ____

    ____ Minutes
    ____ B & W
    ____ Color
    ____ inches

    ____ Minutes
    ____ B & W
    ____ Color
    ____ mm

    ____ B & W
    ____ Color

___ SLIDES

No of frames _____
___ B & W
___ Color
___ Audio
___ Carousel provided
___ Other packaging used
(Specify) _____

___ FILM STRIPS

No of frames _____
___ B & W
___ Color
___ Audio

___ AUDIO

___ Automatic synch
___ _____ Hz
___ Manual cue
___ Reel
___ Cassette
___ Cartridge

___ OTHER

Specify _____

12. Availability:

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14 What level(s) of assistance is required to provide implementation of this outcome?

_____ awareness
X understanding
_____ deciding
X implementing

15. Are Consultive/Inservice (or staff development) available? Yes _____ No _____

Contact: Illinois State Board of Education
Department of Adult, Vocational and Technical Education
Research and Development Section, E-426
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Springfield, IL 62777
(217) 782-4620

16 General Description (State the general objective and suggested method of use. Summarize the content and tell how it is organized. Write the description so that it can be used to promote the material. Continue on back of this sheet or on another sheet, if necessary)

Competency-based task listing by job titles to identify basic skills/knowledge

17 Person Completing this Abstract. Richard W. Glogovsky

Full Address Lake County Area Vocational Center
19525 West Washington Street
Grayslake IL 60030

Zip _____

TASK LISTING BY OCCUPATIONAL TITLES

PROGRAM: INDUSTRIAL ELECTICAL MAINTENANCE

DUTY OCCUPATIONAL SAFETY OPERATION

4/85

TASK NO.	TASK DESCRIPTION	ELECTRICIAN - COMMERCIAL	ELECTRICIAN - RESIDENTIAL	ELECTRICAL/ELECTRONIC TECH.	ELECTRONIC EQUIPMENT MECHANIC	COMPUTER SERVICE TECHNICIAN	APPLIANCE INSTALLER/REPAIRER	ELECTRONIC ASSEMBLER	ELECTRICIAN'S HELPER	ELECTRICAL ENGINEER	ELECTRICAL INSPECTOR						
	Describe Electrical Safety Practice	X	X	X	X	X	X	X	X	X	X						
	Demonstrate Safe Use of Hand Tools	X	X	X	X	X	X	X	X	X	X						
	Identify Hazzards of Static Electricity	X	X	X	X	X	X	X	X	X	X						
	Identify Shock Hazzards	X	X	X	X	X	X	X	X	X	X						

PROGRAM: INDUSTRIAL ELECTICAL MAINTENANCE

DUTY DESIGNING ELECTICAL DIAGRAMS

TASK NO.	TASK DESCRIPTION	ELECTRICIAN - COMMERCIAL	ELECTRICIAN - RESIDENTIAL	ELECTRICAL/ELECTRONIC TECH.	ELECTRONIC EQUIPMENT MECHANIC	COMPUTER SERVICE TECHNICIAN	APPLIANCE INSTALLER/REPAIRER	ELECTRONIC ASSEMBLER	ELECTRICIAN'S HELPER	ELECTRICAL ENGINEER	ELECTRICAL INSPECTOR						
	Identify Electrical circuit & schematic symbols	X	X	X	X	X	X	X	X	X	X						
	Draw a basic electrical circuit using schematic symbols	X	X	X	X	X	X	X	X	X	X						

PROGRAM: INDUSTRIAL ELECTICAL MAINTENANCE

DUTY CONSTRUCTING FUNDAMENTAL D.C. CIRCUIT

TASK NO.	TASK DESCRIPTION	ELECTRICIAN - COMMERCIAL	ELECTRICIAN - RESIDENTIAL	ELECTRICAL/ELECTRONIC TECH.	ELECTRONIC EQUIPMENT MECHANIC	COMPUTER SERVICE TECHNICIAN	APPLIANCE INSTALLER/REPAIRER	ELECTRONIC ASSEMBLER	ELECTRICIAN'S HELPER	ELECTRICAL ENGINEER	ELECTRICAL INSPECTOR						
	Describe Sources of Electricity	X	X	X	X	X	X	X	X	X	X						
	Describe Magnetism	X	X	X	X	X	X	X	X	X	X						
	Identify Battery Characteristics	X	X	X	X	X	X	X	X	X	X						
	Identify Electrical Conductors	X	X	X	X	X	X	X	X	X	X						
	Describe components of D.C. circuit	X	X	X	X	X	X	X	X	X	X						
	Explain OHMS Law	X	X	X	X	X	X	X	X	X	X						
	Differentiate between series & parallel circuits	X	X	X	X	X	X	X	X	X	X						
	Draw a series/parallel circuit	X	X	X	X	X	X	X	X	X	X						
	Construct a series/parallel circuit	X	X	X	X	X	X	X	X	X	X						

PROGRAM: INDUSTRIAL ELECTICAL MAINTENANCE

DUTY CONSTRUCTING FUNDAMENTAL A.C. CIRCUIT

TASK NO.	TASK DESCRIPTION	ELECTRICIAN - COMMERCIAL	ELECTRICIAN - RESIDENTIAL	ELECTRICAL/ELECTRONIC TECH.	ELECTRONIC EQUIPMENT MECHANIC	COMPUTER SERVICE TECHNICIAN	APPLIANCE INSTALLER/REPAIRER	ELECTRONIC ASSEMBLER	ELECTRICIAN'S HELPER	ELECTRICAL ENGINEER	ELECTRICAL INSPECTOR						
	Describe Sources of A.C. Power	X	X	X	X	X	X	X	X	X	X						
	Use Oscilloscope to Identify Wave Forms	X		X	X	X	X			X	X						
	Calculate Inductance	X		X	X	X	X			X	X						
	Calculate Inductive Reactance	X		X	X	X	X			X	X						
	Construct a Seriels RL Circuit	X		X	X	X	X			X	X						
	Measure Voltage Across Resistor & Inductor at Varing Frequencies in a Series RL Circuit	X		X	X	X	X			X	X						
	Calculate Capacitance and Capacitive Reactance	X		X	X	X	X			X	X						
	Construct a Series RC Circuit	X		X	X	X	X			X	X						
	Measure Voltage Across Resistor &																

PROGRAM: INDUSTRIAL ELECTICAL MAINTENANCE

DUTY CONSTRUCTING FUNDAMENTAL A.C. CIRCUIT

TASK NO.	TASK DESCRIPTION	ELECTRICIAN - COMMERCIAL	ELECTRICIAN - RESIDENTIAL	ELECTRICAL/ELECTRONIC TECH.	ELECTRONIC EQUIPMENT MECHANIC	COMPUTER SERVICE TECHNICIAN	APPLIANCE INSTALLER/REPAIRER	ELECTRONIC ASSEMBLER	ELECTRICIAN'S HELPER	ELECTRICAL ENGINEER	ELECTRICAL INSPECTOR						
	Capacitor at Varying Frequencies in a Series RC Circuit	X		X	X	X	X	X	X	X	X						
	Construct a Series RLC Circuit	X		X	X	X	X	X	X	X	X						
	Measure Voltage Across Resistor, Capacitor, & Inductor at Various Values of Capacitane in a Series Circuit	X		X	X	X	X	X	X	X	X						
	Measure Voltage Across Resistor, Capacitor, and Inductor at Various Values of Inductance in a Series Circuit	X		X	X	X	X			X	X						
	Calculate Power Factor	X		X	X	X	X			X	X						
	Construct Parallel RLC Circuit	X		X	X	X	X			X	X						

PROGRAM: INDUSTRIAL ELECTICAL MAINTENANCE

DUTY CONSTRUCTING FUNDAMENTAL A C CIRCUIT

TASK NO.	TASK DESCRIPTION	ELECTRICIAN - COMMERCIAL	ELECTRICIAN - RESIDENTIAL	ELECTRICAL/ELECTRONIC TECH.	ELECTRONIC EQUIPMENT MECHANIC	COMPUTER SERVICE TECHNICIAN	APPLIANCE INSTALLER/REPAIRER	ELECTRONIC ASSEMBLER	ELECTRICIAN'S HELPER	ELECTRICAL ENGINEER	ELECTRICAL INSPECTOR						
	Measure Current Through Resistor, Capacitor, and Inductor at Various Values of Capacitance in a Parallel Circuit	X		X	X	X	X			X	X						
	Measure Current Through Resistor, Capacitor, and Inductor at Various Values of Inductance in a Parallel Circuit	X		X	X	X	X			X	X						
	Calculate Unity Power Factor	X		X	X	X	X			X	X						

PROGRAM: INDUSTRIAL ELECTICAL MAINTENANCE

DUTY INTERPRETING ARCHITECTURAL PLANS

TASK NO.	TASK DESCRIPTION	ELECTRICIAN - COMMERCIAL	ELECTRICIAN - RESIDENTIAL	ELECTRICAL/ELECTRONIC TECH.	ELECTRONIC EQUIPMENT MECHANIC	COMPUTER SERVICE TECHNICIAN	APPLIANCE INSTALLER/REPAIRER	ELECTRONIC ASSEMBLER	ELECTRICIAN'S HELPER	ELECTRICAL ENGINEER	ELECTRICAL INSPECTOR						
	Read Architectural Plans		X				X			X	X						

PROGRAM: INDUSTRIAL ELECTICAL MAINTENANCE

DUTY CALCULATING RESIDENTIAL CIRCUIT REQUIREMENT

TASK NO.	TASK DESCRIPTION	ELECTRICIAN - COMMERCIAL	ELECTRICIAN - RESIDENTIAL	ELECTRICAL/ELECTRONIC TECH.	ELECTRONIC EQUIPMENT MECHANIC	COMPUTER SERVICE TECHNICIAN	APPLIANCE INSTALLER/REPAIRER	ELECTRONIC ASSEMBLER	ELECTRICIAN'S HELPER	ELECTRICAL ENGINEER	ELECTRICAL INSPECTOR						
	Identify Feeder and Branch Circuit Requirements	X	X	X						X	X						
	Calculate Feeder and Branch Circuit Requirements	X	X	X						X	X						
	Identify Appliance Circuit Requirements		X							X	X						
	Calculate Appliance Circuite Requirements		X							X	X						
	Identify Service Entrance Requirements	X	X							X	X						
	Calculate Service Entrance Requirements	X	X							X	X						
	Determine Branch Circuites Desired	X	X							X	X						

PROGRAM: INDUSTRIAL ELECTICAL MAINTENANCE

DUTY RUNNING AND INSTALLING CONDUIT

TASK NO.	TASK DESCRIPTION	ELECTRICIAN - COMMERCIAL	ELECTRICIAN - RESIDENTIAL	ELECTRICAL/ELECTRONIC TECH.	ELECTRONIC EQUIPMENT MECHANIC	COMPUTER SERVICE TECHNICIAN	APPLIANCE INSTALLER/REPAIRER	ELECTRONIC ASSEMBLER	ELECTRICIAN'S HELPER	ELECTRICAL ENGINEER	ELECTRICAL INSPECTOR						
	Describe Types of Conduit	X	X	X					X	X	X						
	Demonstrate NEC Procedures for Cutting, Bending, and Connecting Conduit	X	X	X					X	X	X						
	Identify Receptacle Parts	X	X	X					X	X	X						
	Identify Switches and Connections	X	X	X					X	X	X						
	Identify Conduit Run Symbols	X	X	X					X	X	X						
	Draw a Conduit Run	X	X	X					X	X	X						
	Install Conduit between Boxes	X	X	X					X	X	X						

PROGRAM: INDUSTRIAL ELECTICAL MAINTENANCE

DUTY DESIGNING GROUNDING SYSTEM

TASK NO.	TASK DESCRIPTION	ELECTRICIAN - COMMERCIAL	ELECTRICIAN - RESIDENTIAL	ELECTRICAL/ELECTRONIC TECH.	ELECTRONIC EQUIPMENT MECHANIC	COMPUTER SERVICE TECHNICIAN	APPLIANCE INSTALLER/REPAIRER	ELECTRONIC ASSEMBLER	ELECTRICIAN'S HELPER	ELECTRICAL ENGINEER	ELECTRICAL INSPECTOR						
	Identify NEC Articles for Grounding Systems	X	X	X	X	X	X	X	X	X	X						
	Draw a Wiring Diagram for Grounded System	X	X	X	X	X	X	X	X	X	X						

PROGRAM: INDUSTRIAL ELECTICAL MAINTENANCE

DUTY CALCULATING CIRCUIT PROTECTION DEVICES

TASK NO.	TASK DESCRIPTION	ELECTRICIAN - COMMERCIAL	ELECTRICIAN - RESIDENTIAL	ELECTRICAL/ELECTRONIC TECH.	ELECTRONIC EQUIPMENT MECHANIC	COMPUTER SERVICE TECHNICIAN	APPLIANCE INSTALLER/REPAIRER	ELECTRONIC ASSEMBLER	ELECTRICIAN'S HELPER	ELECTRICAL ENGINEER	ELECTRICAL INSPECTOR						
	Identify Fuse Characteristics	X	X	X	X	X	X	X	X	X	X						
	Identify Circuit Breaker Characteristics	X	X	X	X	X	X	X	X	X	X						
	Describe Overload Relay Application	X	X	X	X	X	X	X	X	X	X						
	Identify NEC Articles for Circuit Protection Devices	X	X	X	X	X	X	X	X	X	X						
	Calculate Current for Protection Devices	X	X	X	X	X	X	X	X	X	X						

PROGRAM: INDUSTRIAL ELECTICAL MAINTENANCE

DUTY INSTALLING SERVICE ENTRANCE PANEL

TASK NO.	TASK DESCRIPTION	ELECTRICIAN - COMMERCIAL	ELECTRICIAN - RESIDENTIAL	ELECTRICAL/ELECTRONIC TECH.	ELECTRONIC EQUIPMENT MECHANIC	COMPUTER SERVICE TECHNICIAN	APPLIANCE INSTALLER/REPAIRER	ELECTRONIC ASSEMBLER	ELECTRICIAN'S HELPER	ELECTRICAL ENGINEER	ELECTRICAL INSPECTOR						
	Select Appropriate Service Entrance Material	X	X	X	X	X	X		X	X	X						
	Identify Proper Service Wiring	X	X	X	X	X	X		X	X	X						
	Install & Wire Service Entrance Panel	X	X	X	X	X	X		X	X	X						

PROGRAM: INDUSTRIAL ELECTICAL MAINTENANCE

DUTY CALCULATING WIRE SIZE & DERATING

TASK NO.	TASK DESCRIPTION	ELECTRICIAN - COMMERCIAL	ELECTRICIAN - RESIDENTIAL	ELECTRICAL/ELECTRONIC TECH.	ELECTRONIC EQUIPMENT MECHANIC	COMPUTER SERVICE TECHNICIAN	APPLIANCE INSTALLER/REPAIRER	ELECTRONIC ASSEMBLER	ELECTRICIAN'S HELPER	ELECTRICAL ENGINEER	ELECTRICAL INSPECTOR						
	Identify Wire Size	X	X	X	X	X	X	X	X	X	X						
	Identify Type of Wire Insulation																
	as recommended by NEC	X	X	X	X	X	X	X	X	X	X						
	Calculate Wire Derating																
	IDentify Wire Sizes	X	X	X	X	X	X	X	X	X	X						
	Cacluate for Wire Derating Factors	X	X	X	X	X	X	X	X	X	X						

PROGRAM: INDUSTRIAL ELECTICAL MAINTENANCE

DUTY ROUGHING A HOUSE

TASK NO.	TASK DESCRIPTION	ELECTRICIAN - COMMERCIAL	ELECTRICIAN - RESIDENTIAL	ELECTRICAL/ELECTRONIC TECH.	ELECTRONIC EQUIPMENT MECHANIC	COMPUTER SERVICE TECHNICIAN	APPLIANCE INSTALLER/REPAIRER	ELECTRONIC ASSEMBLER	ELECTRICIAN'S HELPER	ELECTRICAL ENGINEER	ELECTRICAL INSPECTOR						
	Demonstrate Attaching Conduit to Support Mechanism		X				X		X		X						
	Demonstrate Running Conduit Through Masonary Obstacles		X				X		X		X						
	Demonstrate Proper Wire Pulling Methods		X				X		X		X						

PROGRAM: INDUSTRIAL ELECTICAL MAINTENANCE

DUTY FINISHING A HOUSE

TASK NO.	TASK DESCRIPTION	ELECTRICIAN - COMMERCIAL	ELECTRICIAN - RESIDENTIAL	ELECTRICAL/ELECTRONIC TECH.	ELECTRONIC EQUIPMENT MECHANIC	COMPUTER SERVICE TECHNICIAN	APPLIANCE INSTALLER/REPAIRER	ELECTRONIC ASSEMBLER	ELECTRICIAN'S HELPER	ELECTRICAL ENGINEER	ELECTRICAL INSPECTOR						
	Install Protective Devices		X														
	Install Electrical Devices		X						X		X						
	Install Appliance Branches		X						X		X						

PROGRAM: INDUSTRIAL ELECTICAL MAINTENANCE

DUTY INSTALLING LUMINARY FIXTURES

TASK NO.	TASK DESCRIPTION	ELECTRICIAN - COMMERCIAL	ELECTRICIAN - RESIDENTIAL	ELECTRICAL/ELECTRONIC TECH.	ELECTRONIC EQUIPMENT MECHANIC	COMPUTER SERVICE TECHNICIAN	APPLIANCE INSTALLER/REPAIRER	ELECTRONIC ASSEMBLER	ELECTRICIAN'S HELPER	ELECTRICAL ENGINEER	ELECTRICAL INSPECTOR						
	Identify Installation Procedures for Luminary Fixtures	X	X	X					X	X	X						
	Describe Luminary Fixtures	X	X	X					X	X	X						
	Install Luminary Fixtures	X	X	X					X	X	X						

PROGRAM: INDUSTRIAL ELECTICAL MAINTENANCE

DUTY INSTALLING ELECTRICAL ENVRIONMENTAL CONTROL SYSTEMS

TASK NO.	TASK DESCRIPTION	ELECTRICIAN - COMMERCIAL	ELECTRICIAN - RESIDENTIAL	ELECTRICAL/ELECTRONIC TECH.	ELECTRONIC EQUIPMENT MECHAN	COMPUTER SERVICE TECHNICIAN	APPLIANCE INSTALLER/REPAIRER	ELECTRONIC ASSEMBLER	ELECTRICIAN'S HELPER	ELECTRICAL ENGINEER	ELECTRICAL INSPECTOR						
	Identify Heating System Components	X	X	X			X				X						
	Identify NEC Articles for Heating Devices	X	X	X			X				X						
	Connect A.C. Power to Heating Device	X	X	X			X				X						
	Identify Air Conditioning Electrical Requirements	X	X	X			X				X						
	Connect Air Conditioning Power	X	X	X			X				X						

PROGRAM: INDUSTRIAL ELECTICAL MAINTENANCE

DUTY INSTALLING LOW VOLTAGE POWER DEVICES

TASK NO.	TASK DESCRIPTION	ELECTRICIAN - COMMERCIAL	ELECTRICIAN - RESIDENTIAL	ELECTRICAL/ELECTRONIC TECH.	ELECTRONIC EQUIPMENT MECHANIC	COMPUTER SERVICE TECHNICIAN	APPLIANCE INSTALLER/REPAIRER	ELECTRONIC ASSEMBLER	ELECTRICIAN'S HELPER	ELECTRICAL ENGINEER	ELECTRICAL INSPECTOR						
	Identify Circuit Symbols	X	X	X	X	X	X	X	X	X	X						
	Identify All Low Voltage Power Devices	X	X	X	X	X	X	X	X	X	X						
	Identify Componets in a Low Power Circuit	X	X	X	X	X	X	X	X	X	X						
	Connect Low Power Devices	X	X	X	X	X	X	X	X	X	X						

PROGRAM: INDUSTRIAL ELECTICAL MAINTENANCE

DUTY CONNECTING TRANSFORMERS

TASK NO.	TASK DESCRIPTION	ELECTRICIAN - COMMERCIAL	ELECTRICIAN - RESIDENTIAL	ELECTRICAL/ELECTRONIC TECH.	ELECTRONIC EQUIPMENT MECHAN.	COMPUTER SERVICE TECHNICIAN	APPLIANCE INSTALLER/REPAIRER	ELECTRONIC ASSEMBLER	ELECTRICIAN'S HELPER	ELECTRICAL ENGINEER	ELECTRICAL INSPECTOR						
	Identify Three Phase Sine Wave Components	X		X	X		X				X						
	Discuss Transformer Impedance	X		X	X		X				X						
	Describe Transformer Construction Elements	X		X	X		X				X						
	Identify Delta and Wye Connections	X		X	X		X				X						
	Connect Transform for Three Phase Wye Operation	X		X	X		X				X						
	Connect Transformer for Three Phase Delta Operation	X		X	X		X				X						
	Connect Two Single Phase Transformer in Parallel	X		X	X		X				X						
	Connect Dual Voltage Transformer	X		X	X		X				X						

PROGRAM: INDUSTRIAL ELECTICAL MAINTENANCE

DUTY CONNECTING & MAINTAING AC/DC ROTATING EQUIPMENT

TASK NO.	TASK DESCRIPTION	ELECTRICIAN - COMMERCIAL	ELECTRICIAN - RESIDENTIAL	ELECTRICAL/ELECTRONIC TECH.	ELECTRONIC EQUIPMENT MECHANIC	COMPUTER SERVICE TECHNICIAN	APPLIANCE INSTALLER/REPAIRER	ELECTRONIC ASSEMBLER	ELECTRICIAN'S HELPER	ELECTRICAL ENGINEER	ELECTRICAL INSPECTOR						
	Describe Electrical System Work	X		X			X										
	Identify Sources of Counter Electromotive Forces	X		X			X										
	Describe Armature Characteristics	X		X			X										
	Connect DC Motor for Series & Shunt Operations	X		X			X										
	Maintain DC Motors	X		X			X										
	Describe Single Phase Starting Tech.	X		X			X										
	Describe Three Phase Induction Motor	X		X			X										
	Describe Synchronous Motor	X		X			X										
	Connect Delta & Wye Motor	X		X			X										
	Maintain AC Motor	X		X			X										
	Describe Motor Performance Character	X		X			X										

PROGRAM: INDUSTRIAL ELECTICAL MAINTENANCE

DUTY CONSTRUCTING POWER SUPPLIES

TASK NO.	TASK DESCRIPTION	ELECTRICIAN - COMMERCIAL	ELECTRICIAN - RESIDENTIAL	ELECTRICAL/ELECTRONIC TECH.	ELECTRONIC EQUIPMENT MECHANIC	COMPUTER SERVICE TECHNIGIAN	APPLIANCE INSTALLER/REPAIRER	ELECTRONIC ASSEMBLER	ELECTRICIAN'S HELPER	ELECTRICAL ENGINEER	ELECTRICAL INSPECTOR						
	Construct a Transformer	X		X	X	X	X			X	X						
	Construct Regulated Power Supply	X		X	X	X	X			X	X						
	Construct Overcurrent Protector	X		X	X	X	X			X	X						
	Identify Components of Switching Power Supply.	X		X	X	X	X			X	X						
	Test Switching Power Supply	X		X	X	X	X			X	X						

PROGRAM: INDUSTRIAL ELECTICAL MAINTENANCE

DUTY CONNECTING MANUAL PROCESS CONTROL DEVICES

TASK NO.	TASK DESCRIPTION	ELECTRICIAN - COMMERCIAL	ELECTRICIAN - RESIDENTIAL	ELECTRICAL/ELECTRONIC TECH.	ELECTRONIC EQUIPMENT MECHANIC	COMPUTER SERVICE TECHNICIAN	APPLIANCE INSTALLER/REPAIRER	ELECTRONIC ASSEMBLER	ELECTRICIAN'S HELPER	ELECTRICAL ENGINEER	ELECTRICAL INSPECTOR						
	Identify Manual Process Control Devices	X		X	X	X	X	X		X	X						
	Describe Ladder Diagram Symbols	X		X	X	X	X	X		X	X						
	Connect Manual Process Control Devices	X		X	X	X	X	X		X	X						

PROGRAM: INDUSTRIAL ELECTICAL MAINTENANCE

DUTY CONNECTING PROCESS SENSOR JUNCTIONS

TASK NO.	TASK DESCRIPTION	ELECTRICIAN - COMMERCIAL	ELECTRICIAN - RESIDENTIAL	ELECTRICAL/ELECTRONIC TECH.	ELECTRONIC EQUIPMENT MECHAN.	COMPUTER SERVICE TECHNICIAN	APPLIANCE INSTALLER/REPAIRER	ELECTRONIC ASSEMBLER	ELECTRICIAN'S HELPER	ELECTRICAL ENGINEER	ELECTRICAL INSPECTOR						
	Identify Chemical Sensor Junctions	X		X	X	X	X	X		X	X						
	Connect Chemical Sensor Junction Devices	X		X	X	X	X	X		X	X						
	Identify Radiant Sensor Junctions	X		X	X	X	X	X		X	X						
	Connect Radiant Sensor Junction Devices	X		X	X	X	X	X		X	X						
	Identify Semi-Conductor Sensor Junctions	X		X	X	X	X	X		X	X						
	Connect Semi-Conductor Sensor Junction Devices	X		X	X	X	X	X		X	X						
	Identify Pressure Sensing Devices	X		X	X	X	X	X		X	X						
	Connect Pressure Sensing Devices	X		X	X	X	X	X		X	X						
	Identify Magnetic Sensing Devices	X		X	X	X	X	X		X	X						

PROGRAM: INDUSTRIAL ELECTICAL MAINTENANCE

DUTY CONNECTING PROCESS SENSOR JUNCTIONS

TASK NO.	TASK DESCRIPTION	ELECTRICIAN - COMMERCIAL	ELECTRICIAN - RESIDENTIAL	ELECTRICAL/ELECTRONIC TECH.	ELECTRONIC EQUIPMENT MECHANIC	COMPUTER SERVICE TECHNICIAN	APPLIANCE INSTALLER/REPAIRER	ELECTRONIC ASSEMBLER	ELECTRICIAN'S HELPER	ELECTRICAL ENGINEER	ELECTRICAL INSPECTOR						
	Connect Magnetic Sensing Devices	X		X	X	X	X	X		X	X						
	Identify Mechanical Position Sensor	X		X	X	X	X	X		X	X						
	Connect Mechanical Sensors	X		X	X	X	X	X		X	X						
	Identify Ladder Diagram Symbol for Process Devices	X		X	X	X	X	X		X	X						

PROGRAM: INDUSTRIAL ELECTICAL MAINTENANCE

DUTY CONNECTING SIGNAL PROCESSORS

TASK NO.	TASK DESCRIPTION	ELECTRICIAN - COMMERCIAL	ELECTRICIAN - RESIDENTIAL	ELECTRICAL/ELECTRONIC TECH.	ELECTRONIC EQUIPMENT MECHAN	COMPUTER SERVICE TECHNICIAN	APPLIANCE INSTALLER/REPAIRER	ELECTRONIC ASSEMBLER	ELECTRICIAN'S HELPER	ELECTRICAL ENGINEER	ELECTRICAL INSPECTOR						
	Identify Operational Amplifiers	X		X	X	X	X	X		X	X						
	Connect Operational Amplifiers	X		X	X	X	X	X		X	X						
	Identify Pulse Generators	X		X	X	X	X	X		X	X						
	Connect Pulse Generators	X		X	X	X	X	X		X	X						
	Identify DC to AC Converters	X		X	X	X	X	X		X	X						
	Connect DC to AC Concerter	X		X	X	X	X	X		X	X						
	Identify AC to DC Converter	X		X	X	X	X	X		X	X						
	Connect AC to DC Converter	X		X	X	X	X	X		X	X						
	Identify Signal Conditioning Circuit	X		X	X	X	X	X		X	X						
	Connect Signal Conditioning Circuit	X		X	X	X	X	X		X	X						

PROGRAM: INDUSTRIAL ELECTICAL MAINTENANCE

DUTY CONNECTING PROCESS LOGIC DEVICES

TASK NO.	TASK DESCRIPTION	ELECTRICIAN - COMMERCIAL	ELECTRICIAN - RESIDENTIAL	ELECTRICAL/ELECTRONIC TECH.	ELECTRONIC EQUIPMENT MECHANIC	COMPUTER SERVICE TECHNICIAN	APPLIANCE INSTALLER/REPAIRER	ELECTRONIC ASSEMBLER	ELECTRICIAN'S HELPER	ELECTRICAL ENGINEER	ELECTRICAL INSPECTOR						
	Identify Gate Logic Devices	X		X	X	X	X	X		X	X						
	Connect Gate Logic Devices	X		X	X	X	X	X		X	X						
	Identify Timing Logic Devices	X		X	X	X	X	X		X	X						
	Connect Timing Logic Devices	X		X	X	X	X	X		X	X						
	Identify Counting Devices	X		X	X	X	X	X		X	X						
	Connect Counting Devices	X		X	X	X	X	X		X	X						
	Identify Ladder Diagram Symbols for Process Logic Devices	X		X	X	X	X	X		X	X						

PROGRAM: INDUSTRIAL ELECTICAL MAINTENANCE

DUTY INSTALLING AND MAINTAINING PROCESS ACTUATORS

TASK NO.	TASK DESCRIPTION	ELECTRICIAN - COMMERCIAL	ELECTRICIAN - RESIDENTIAL	ELECTRICAL/ELECTRONIC TECH.	ELECTRONIC EQUIPMENT MECHAN.	COMPUTER SERVICE TECHNICIAN	APPLIANCE INSTALLER/REPAIRER	ELECTRONIC ASSEMBLER	ELECTRICIAN'S HELPER	ELECTRICAL ENGINEER	ELECTRICAL INSPECTOR						
	Identify Fluid System Symbols	X		X	X	X	X			X	X						
	Describe Unified Technology Concepts	X		X	X	X	X			X	X						
	Connect Fluid System Valves	X		X	X	X	X			X	X						
	Identify Fluid System Components	X		X	X	X	X			X	X						
	Connect Fluid System Components	X		X	X	X	X			X	X						
	Connect Venturi Vacuum Generator	X		X	X	X	X			X	X						
	Describe Pressure and Force in a Fluid System	X		X	X	X	X			X	X						
	Describe Fluid Conditioners	X		X	X	X	X			X	X						
	Connect Pneumatic Arm Controlls	X		X	X	X	X			X	X						
	Troubleshoot Fluid System	X		X	X	X	X			X	X						

PROGRAM: INDUSTRIAL ELECTICAL MAINTENANCE

DUTY IDENTIFYING PROCESS SYSTEM COMPONENT

TASK NO.	TASK DESCRIPTION	ELECTRICIAN - COMMERCIAL	ELECTRICIAN - RESIDENTIAL	ELECTRICAL/ELECTRONIC TECH.	ELECTRONIC EQUIPMENT MECHANIC	COMPUTER SERVICE TECHNICIAN	APPLIANCE INSTALLER/REPAIRER	ELECTRONIC ASSEMBLER	ELECTRICIAN'S HELPER	ELECTRICAL ENGINEER	ELECTRICAL INSPECTOR						
	Describe Telemetry Components			X		X				X							
	Describe System Interface Component			X		X				X							
	Describe Process Control Components			X		X				X							

PROGRAM: INDUSTRIAL ELECTICAL MAINTENANCE

DUTY CLASSIFYING ROBOTS & ROBOTIC CONTROL ELEMENTS

TASK NO.	TASK DESCRIPTION	ELECTRICIAN - COMMERCIAL	ELECTRICIAN - RESIDENTIAL	ELECTRICAL/ELECTRONIC TECH.	ELECTRONIC EQUIPMENT MECHAN.	COMPUTER SERVICE TECHNICIAN	APPLIANCE INSTALLER/REPAIRER	ELECTRONIC ASSEMBLER	ELECTRICIAN'S HELPER	ELECTRICAL ENGINEER	ELECTRICAL INSPECTOR						
	Describe Robotic Types	X		X	X	X				X							
	Describe Robotic Control Parts	X		X	X	X				X							
	Describe Feedback Signal Systems	X		X	X	X				X							

PROGRAM: INDUSTRIAL ELECTICAL MAINTENANCE

DUTY IDENTIFYING ROBOTIC SYSTEM COMPONENTS

ASK NO.	TASK DESCRIPTION	ELECTRICIAN - COMMERCIAL	ELECTRICIAN - RESIDENTIAL	ELECTRICAL/ELECTRONIC TECH.	ELECTRONIC EQUIPMENT MECHANIC	COMPUTER SERVICE TECHNICIAN	APPLIANCE INSTALLER/REPAIRER	ELECTRONIC ASSEMBLER	ELECTRICIAN'S HELPER	ELECTRICAL ENGINEER	ELECTRICAL INSPECTOR						
	Identify Robotic System Mechanical Parts	X		X	X	X				X							
	Identify BRAT 800 Pneumatic Actuator Parts	X		X	X	X				X							

PROGRAM: INDUSTRIAL ELECTICAL MAINTENANCE

DUTY PROGRAMMING BRAT 800

TASK NO.	TASK DESCRIPTION	ELECTRICIAN - COMMERCIAL	ELECTRICIAN - RESIDENTIAL	ELECTRICAL/ELECTRONIC TECH.	ELECTRONIC EQUIPMENT MECHAN	COMPUTER SERVICE TECHNICIAN	APPLIANCE INSTALLER/REPAIRER	ELECTRONIC ASSEMBLER	ELECTRICIAN'S HELPER	ELECTRICAL ENGINEER	ELECTRICAL INSPECTOR						
	Write a Robotic Program			X	X	X				X							
	Test Program via Magnetic Logic Device			X	X	X				X							
	Program Robot with Drum Controller			X	X	X				X							
	Operate Programmed Robot			X	X	X				X							

PROGRAM: INDUSTRIAL ELECTICAL MAINTENANCE

DUTY TROUBLESHOOTING BASIC SYSTEMS

TASK NO.	TASK DESCRIPTION	ELECTRICIAN - COMMERCIAL	ELECTRICIAN - RESIDENTIAL	ELECTRICAL/ELECTRONIC TECH.	ELECTRONIC EQUIPMENT MECHANIC	COMPUTER SERVICE TECHNICIAN	APPLIANCE INSTALLER/REPAIRER	ELECTRONIC ASSEMBLER	ELECTRICIAN'S HELPER	ELECTRICAL ENGINEER	ELECTRICAL INSPECTOR						
	Troubleshoot and Repair Control Circuits and Control Devices	X		X	X	X											
	Troubleshoot using Electrical Schematics, Building Plans, and Ladder Diagrams	X		X	X	X											
	Identify Troubleshooting Short Cuts	X		X	X	X											
	Troubleshoot Input and Output Instrumentation Devices	X		X	X	X											
	Troubleshoot Integrated Circuit Logic Devices	X		X	X	X											
	Troubleshoot Programmable Controller			X	X	X											
	Troubleshoot Microprocessor Logic System			X		X											

APPENDIX II

Machine Shop Learning Guides

Illinois State Board of Education

Department of Adult, Vocational and Technical Education
Research and Development Section

Product Abstract

1. Title of material: 3 Machine Shop Learning Guides - titles listed on reverse side

2. Date material was completed: FY85

3. Please check one: New material X Revised material ____ Field-tested material ____

4. Originating agency: Lake County Area Vocational Center

   Address: 19525 W. Washington St., Grayslake IL Zip Code: 60030

5. Name(s) of developer(s): Wilfred Pouler

   Address: Lake County Area Vocational Center Zip Code: ____

6. Developed pursuant to Contract Number: F-99-25-X-0000-499

7. Subject Matter (Check only one according to Department of Education Code):

   Code

   ____ 01 Agricultural Education
   ____ 03 Business and Office Education
   ____ 04 Distributive Education
   ____ 07 Health Occupations Education
   ____ 09 Home Economics Education
   ____ 10 Industrial Arts Education
   ____ 16 Technical Education
   X 17 Trade and Industrial Education
   ____ 22 Cooperative Education
   ____ Career Education
   ____ Other (Specify) ____

8. Education Level:

   ____ Pre-K Thru 6
   ____ 7-8
   ____ 9-10
   X 11-12
   X Post-Secondary
   X Adult
   ____ Teacher (Pre-service)
   ____ Administrator (Pre-Service)
   ____ Other (Specify) ____

9. Intended for Use By:

   X Student
   X Classroom Teacher
   X Local Administrator
   ____ Teacher Educator
   ____ Guidance Staff
   ____ State Personnel
   ____ Other (Specify) ____

10. Student Type:

    X Regular
    ____ Disadvantaged
    ____ Handicapped
    ____ Limited-English Proficiency
    ____ Other (Specify) ____

11. Medium and Format of Materials:

    X HARDCOPY
    ____ VIDEOTAPE
    ____ FILM
    ____ MICROFICHE

    No. of pages various
    ____ Paper bound
    ____ Hard bound
    X Loose-leaf
    Photos: Yes ____ No ____
    Diagrams: Yes ____ No ____

    ____ Minutes
    ____ B & W
    ____ Color
    ____ inches

    ____ Minutes
    ____ B & W
    ____ Color
    ____ mm

    ____ B & W
    ____ Color

___ SLIDES

No of frames _____
___ B & W
___ Color
___ Audio
___ Carousel provided
___ Other packaging used
(Specify) _____

___ FILM STRIPS

No of frames _____
___ B & W
___ Color
___ Audio

___ AUDIO

___ Automatic synch
___ _____ Hz
___ Manual cue
___ Reel
___ Cassette
___ Cartridge

___ OTHER

Specify:
_____
_____
_____

12. Availability:

_____ One copy free
X In ERIC system (No. _____)
For sale @ $ _____ per copy
_____ Not available
_____ Loan copy available

Contact: Name East Central Network for Curriculum Coord. Phone (217) 786-6375
Illinois Vocational Curriculum Center
Address Sangamon State University, Building F Zip Code 62708
Springfield IL

13. Copyright Restrictions:

Contact: Name NONE Phone ( )
Address Zip Code

14 What level(s) of assistance is required to provide implementation of this outcome?

_____ awareness
X understanding
_____ deciding
X implementing

15. Are Consultive/Inservice (or staff development) available? Yes_____ No_____

Contact: Illinois State Board of Education
Department of Adult, Vocational and Technical Education
Research and Development Section, E-426
100 North First Street
Springfield, IL 62777
(217) 782-4620

16 General Description (State the general objective and suggested method of use. Summarize the content and tell how it is organized. Write the description so that it can be used to promote the material. Continue on back of this sheet or on another sheet, if necessary)

Competency-based learning guides for learning basic skills/knowledge

17 Person Completing this Abstract: Richard W. Glogovsky

Full Address
Lake County Area Vocational Center
19525 West Washington Street
Grayslake IL 60030

LEARNING GUIDE TITLES:

1. Write a numerical control program for drilling and tapping operations
2. Tape and punch NC program. Dry run program and perform machining operations (rough draft)
3. Develop an NC program for a straight slot using a vertical milling machine and perform the machining operation for this NC program (rough draft)

LAKE
COUNTY
AREA
VOCATIONAL
CENTER

COMPETENCY-BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

STUDENT LEARNING GUIDE

Produced By W. Pouler Date 2/85

TASK: WRITE A NUMERICAL CONTROL PROGRAM FOR DRILLING AND TAPPING OPERATIONS

PURPOSE: This guide will explain the steps used in writing a numerical control (NC) or computer numerical control (CNC) machining program. The part print will be analyzed to determine the machine tool, process steps, tooling, holding fixture and starting point. The sequence of operations, positioning, speeds and feeds, and other data will be entered on the program manuscript. The program will be proofread and dry run.

MACHINE SHOP

Program	Task	Est.Time	Prereq.
48.0503	032	10 hours	031

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME _____ SOCIAL SECURITY NUMBER _____

LENGTH OF CONTRACT (NORMAL TIME IN HOURS) _____

2. TERMINAL PERFORMANCE OBJECTIVE

Given: The necessary information, supplies and equipment

You will: Write a numerical control program for drilling and tapping operations

How well: To master this task you must score 80 out of 106 points to score 77 % on a programming form.

2a. INTERMEDIATE OBJECTIVE(s)

1. Identify steps used in writing an NC program
2. Identify fixture, clamps, zero location point and part setup point
3. Calculate R and Z depths
4. Develop NC program operation steps
5. Develop an NC program

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____. I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

Student's Signature _____

Instructor's Signature (verifies competency) _____

INTERMEDIATE OBJECTIVE

1. Identify steps used in writing an NC program

LEARNING STEPS (Activities)

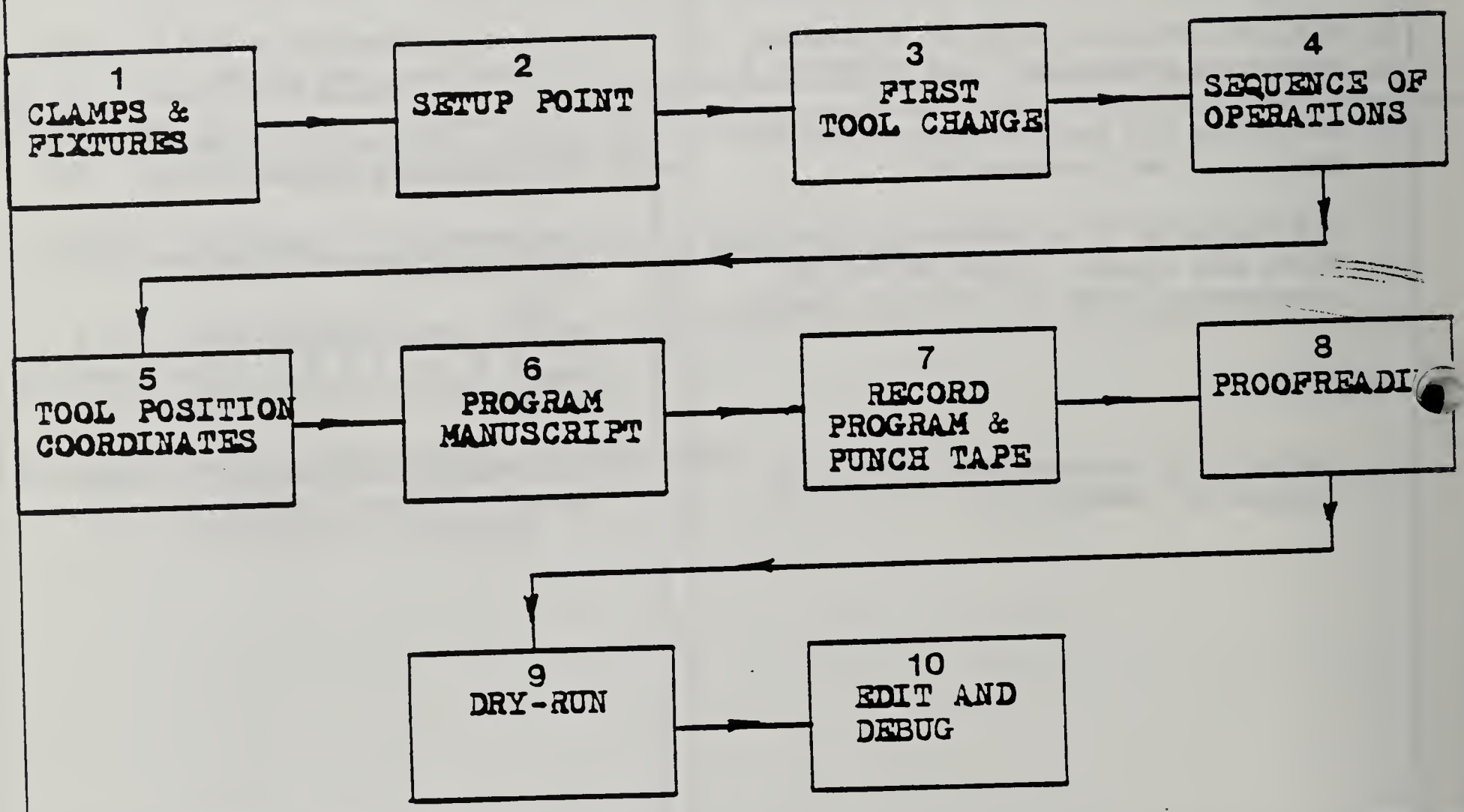
1. Read resource #1 to learn about the steps used in writing an NC program.
2. Analyze the part print to determine machining processes - see resource #2.
3. Determine the tooling needed for this project - see resource #3.
4. See resource #4 to determine machining feeds and speeds. List values on information sheet #3 (Tooling Sheet).
5. Go to next intermediate objective listed in resource #5.

RESOURCES

1. Review information sheet #1, page 4 in this learning guide.
2. Review information sheet #2, page 5 in this learning guide.
3. Review information sheet #2, page 5 in this learning guide.
4. Fundamentals of Numerical Control, pages 230-232
   and
   Information sheets #3, 4, 5 & 6, pages 6, 7, 8 & 9 in this learning guide
5. Intermediate objective #2, page 10 in this learning guide.

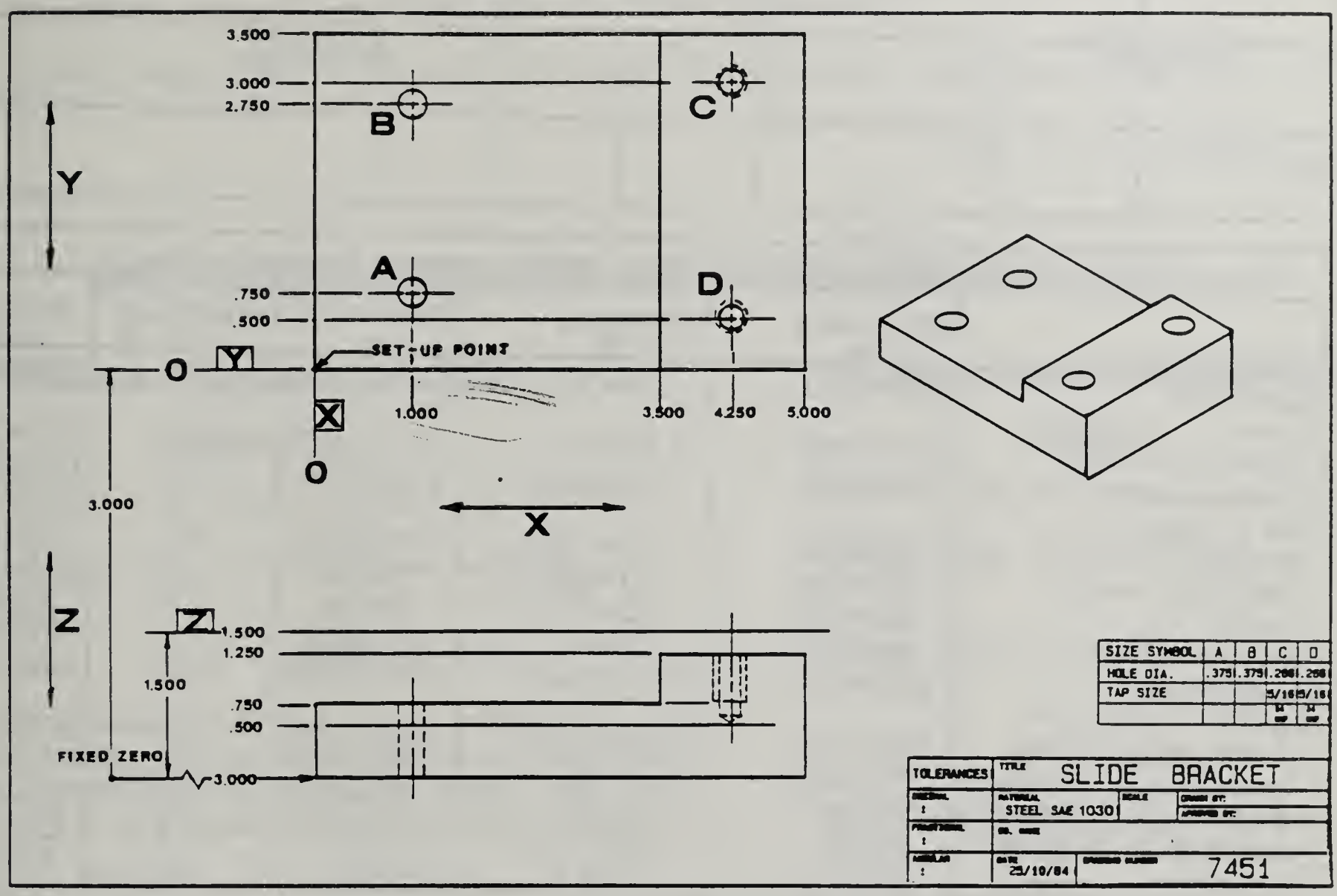
INFORMATION SHEET #1

BASIC PROGRAMMING STEPS



INFORMATION SHEET #2

PART PRINT



Program	Task	Page
48.0503	032	5

TOOLING SHEET

Part No. _____
Part Name _____
Customer _____
Material _____

Programmer _____
Date _____

Tool Position	Offset Number	Tool Description	Tool Number	Speed rpm	Feed ipm	Comments

Suggested Cutting Rates Using High Speed Steel Cutting Tools

Material	Drilling sfm	Reaming sfm	Turning sfm	Tapping sfm *	Milling sfm
Aluminum	250-600	100-300	400-1000	90	300-800
Brass free cutting	150-300	130-200	225-350	100	150-300
Bronze, soft	100-250	75-180	150-225	75	100-250
Cast iron					
Soft	75-150	60-100	100-150	40	75-150
Medium	70-100	30-65	75-120	30	70-100
Hard	60-100	20-55	50-90	20	50-80
Copper	60-100	40-60	100-200	40	80-140
Magnesium	300-650	150-350	600-1200	150	300-600
Steel					
Free machining	100-145	60-100	125-200	40	100-180
Under 0.3 carbon	70-120	50-90	75-175	35	70-120
0.3 to 0.6 carbon	55-90	45-70	65-120	25	55-90
Over 0.6 carbon	40-60	40-50	60-80	20	40-60
Titanium	30-60	10-20	25-55	30	25-50

* Suggested rates - machining variables may require changing rates.

Cutting rate can be converted to spindle speed by using the formula:

(Basic formula)

$$\text{rpm} = \frac{\text{sfm} \times 12}{\pi \times \text{diameter of cutter}}$$

(Simplied formula)

$$\text{rpm} = \frac{C \times \text{sfm}}{\text{diameter of cutter}}$$

Constant "C" = 4

Example

3/8 drill in SAE 1030 steel

$$\text{rpm} = \frac{4 \times 70}{.375}$$

rpm = 746

Rounded off rpm = 750

DRILLING FEED RATE

Recommended Feeds For Drilling	
Diameter of Drill (inches)	Feed (inches per revolution)
under 1/8	.001 to .002
1/8 to 1/4	.002 to .004
1/4 to 1/2	.004 to .007
1/2 to 1	.007 to .015
1 inch and over	.015 to .025

Formula

Feed rate(IPM) = Feed(IPR) x spindle speed

Example

3/8 drill in SAE 1030 steel

Feed rate = .004 x 746
= 2.984(IPM)

TAPPING SPINDLE RATE (RPM) AND CUTTING FEED RATE (IPM)

Tapping spindle rate(RPM)

Example

5/16 - 24 tap in SAE 1030 steel

$$\text{Spindle rate(RPM)} = \frac{4 \times 35}{.3125}$$

RPM = 448 *

* Because of the many variables in cutting threads using a tap, some production machine shops use 25% of the calculated spindle rate.

25% of 448 = 112 RPM

Tapping cutting feed rate(IPM)

Example

5/16 - 24 tap in SAE 1030 steel

Feed rate = Lead(IPR) or
Lead x RPM

Feed rate = .0417 x 112
= 4.67 (IPM)

$$\text{Lead} = \frac{1}{\text{threads per inch}}$$

$$\text{Lead} = \frac{1}{24}$$

Lead = .0417

THREAD ELEMENTS AND TAP DRILL SIZES

Thread Elements and Tap Drill Sizes Unified National Coarse Thread Series

Sizes	Threads Per Inch	DIAMETERS (Basic) Major Diameter — Inches	Pitch Diameter — Inches	Minor Diameter Inches Ext. Thds.	Minor Diameter Inches Int. Thds.	TAP DRILLS Tap Drill To Produce Approx. 75% Full Thread	Decimal Equivalent of Tap Drill — Inches
1	64	.073	.0629	.0538	.0561	No. 53	.0595
2	56	.086	.0744	.0641	.0667	No. 50	.0700
3	48	.099	.0855	.0734	.0764	No. 47	.0785
4	40	.112	.0958	.0813	.0849	No. 43	.0890
5	40	.125	.1088	.0943	.0979	No. 38	.1015
6	32	.138	.1177	.0997	.1042	No. 36	.1065
8	32	.164	.1437	.1257	.1302	No. 29	.1360
10	24	.190	.1629	.1389	.1449	No. 25	.1495
12	24	.216	.1889	.1649	.1709	No. 16	.1770
1/4	20	.2500	.2175	.1887	.1959	No. 7	.2010
5/16	18	.3125	.2764	.2443	.2524	Let. F	.2570
3/8	16	.3750	.3344	.2983	.3073	5/16	.3125
7/16	14	.4375	.3911	.3499	.3602	Let. U	.3680
1/2	13	.5000	.4500	.4056	.4167	27/64	4219
9/16	12	.5625	.5084	.4603	.4723	31/64	.4844
5/8	11	.6250	.5660	.5135	.5266	17/32	.5312
3/4	10	.7500	.6850	.6273	.6417	21/32	.6562
7/8	9	.8750	.8028	.7387	.7547	49/64	.7656
1	8	1.0000	.9188	.8466	.8647	7/8	.8750
1 1/8	7	1.1250	1.0322	.9407	.9704	63/64	.9844
1 1/4	7	1.2500	1.1572	1.0747	1.0954	1 7/64	1.1093
1 1/2	6	1.5000	1.3917	1.2955	1.3196	1 11/32	1.4218
1 3/4	5	1.7500	1.6201	1.5046	1.5335	1 9/16	1.5625
2	4 1/2	2.0000	1.8557	1.7274	1.7594	1 25/32	1.7812
2 1/4	4 1/2	2.2500	2.1057	1.9774	2.0094	2 1/32	2.0312
2 1/2	4	2.5000	2.3376	2.1933	2.2294	2 1/4	2.2500
2 3/4	4	2.7500	2.5876	2.4433	2.4794	2 1/2	2.5000
3	4	3.0000	2.8376	2.6933	2.7294	2 3/4	2.7500

THREAD ELEMENTS AND TAP DRILL SIZES

Thread Elements and Tap Drill Sizes Unified National Fine Thread Series

Sizes	Threads Per Inch	DIAMETERS (Basic) Major Diameter — Inches	Pitch Diameter — Inches	Minor Diameter Inches Ext. Thds.	Minor Diameter Inches Int. Thds.	TAP DRILLS Tap Drill To Produce Approx. 75% Full Thread	Decimal Equivalent of Tap Drill — Inches
0	80	.060	.0519	.0447	.0465	3/64	.0469
1	72	.073	.0640	.0560	.0580	No. 53	.0595
2	64	.086	.0759	.0668	.0691	No. 50	.0700
3	56	.099	.0874	.0771	.0797	No. 45	.0820
4	48	.112	.0985	.0864	.0894	No. 42	.0935
5	44	.125	.1102	.0971	.1004	No. 37	.1040
6	40	.138	.1218	.1073	.1109	No. 33	.1130
8	36	.164	.1460	.1299	.1339	No. 29	.1360
10	32	.190	.1697	.1517	.1562	No. 21	.1590
12	28	.216	.1928	.1722	.1773	No. 14	.1820
1/4	28	.2500	.2268	.2060	.2113	No. 3	.2130
5/16	24	.3125	.2854	.2614	.2674	Let. I	2720
3/8	24	.3750	.3479	.3239	.3299	Let. Q	.3346
7/16	20	.4375	.4050	.3762	.3834	25/64	.3906
1/2	20	.5000	.4675	.4387	.4459	29/64	4531
9/16	18	.5625	.5264	.4943	5024	33/64	5156
5/8	18	.6250	.5889	5568	5649	37/64	5781
3/4	16	.7500	.7094	6733	.6823	11/16	.6875
7/8	14	.8750	.8286	.7874	.7977	13/16	8125
1	12	1.0000	.9549	.8978	.9098	59/64	9219
1 1/8	12	1.1250	1.0709	1.0228	1.0348	1 3/64	1.0469
1 1/4	12	1.2500	1.1959	1.1478	1.1598	1 11/64	1.1719
1 1/2	12	1.5000	1.4459	1.3978	1.4098	1 27/64	1.4219

INTERMEDIATE OBJECTIVE

2. Identify fixture, clamps, zero location point and part setup point

LEARNING STEPS (Activities)

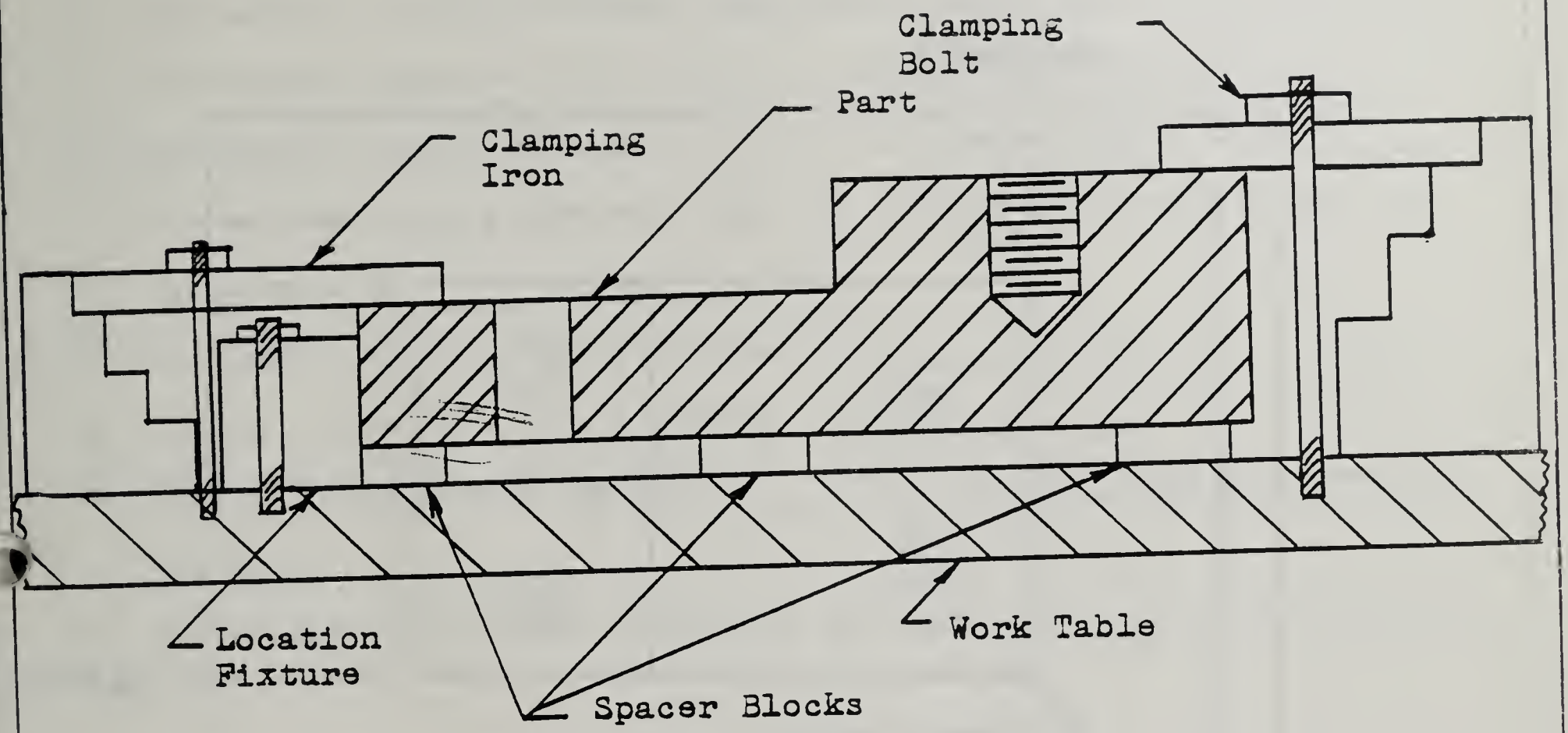
1. Use resource #1 to identify fixture and clamps required to hold piece part.
2. Determine machine start zero point identified in resource #2.
3. Use resource #3 to determine setup point.
4. Complete review exercise listed in resource #4 to check your understanding of intermediate objectives 1 and 2.
5. Use resource #5 to check your answers to review exercise #1.
6. To correct any wrong answers on review exercise #1, re-read resources #3 & 4.
7. Go to next intermediate objective listed in resource #7.

RESOURCES

1. Information sheet #7, page 11 in this learning guide.
2. Information sheet #8, page 12 in this learning guide.
3. Information sheet #8, page 12 in this learning guide
   and
   Terco CNC Milltrainer Manual, page 12
4. Review exercise #1, page 13 in this learning guide.
5. Answer sheet for review exercise #1 on page 26 in this learning guide.
6. See resources #3 & 4 above.
7. Intermediate objective #3, page 14 in this learning guide.

INFORMATION SHEET # 7

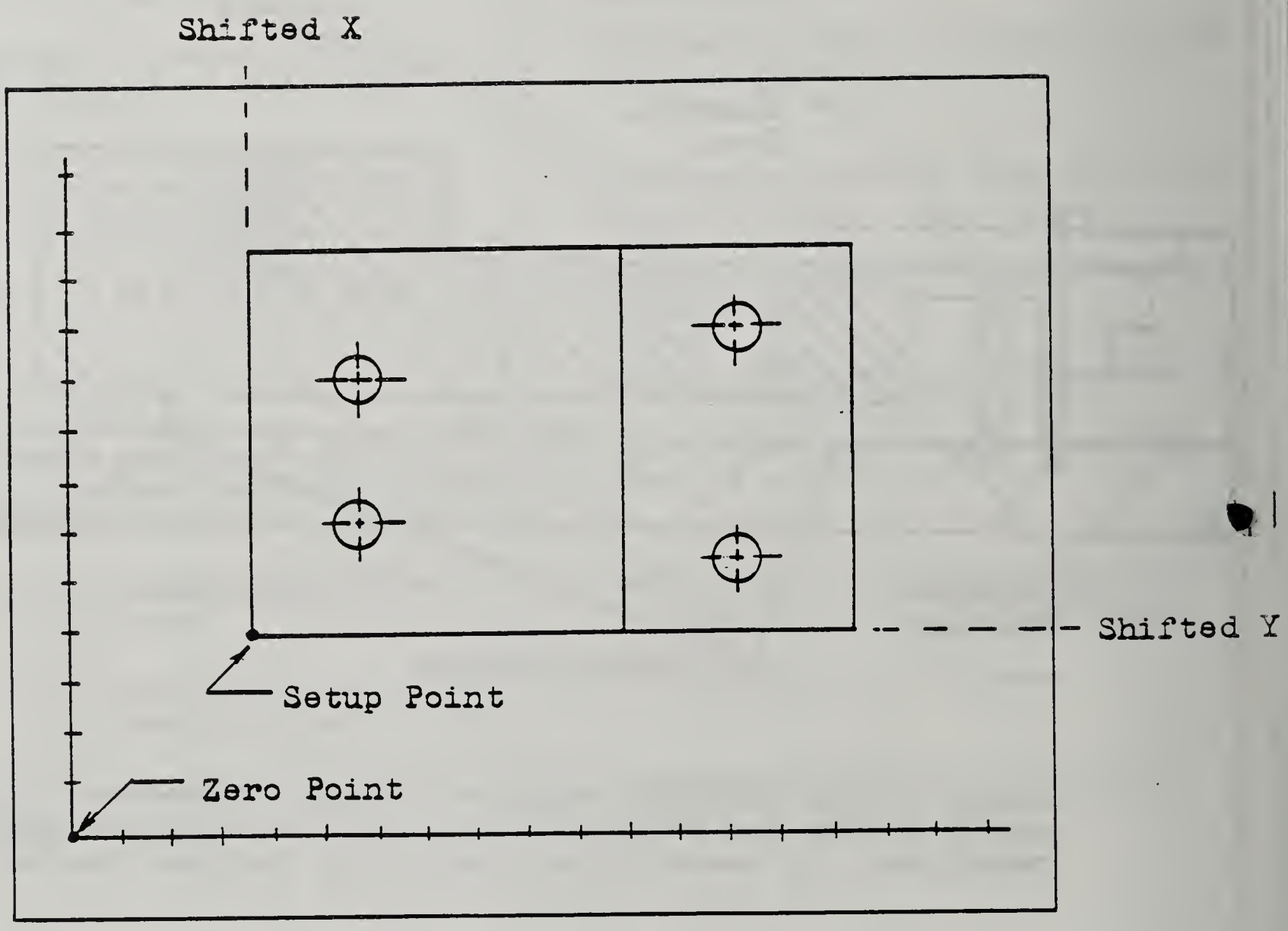
FIXTURE AND CLAMPING



Spacer blocks used for machine through clearance.
Spacer blocks not required for blind drilling or machining operations not penetrating completely through the part.

INFORMATION SHEET # 8

ZERO POINT AND SETUP POINT



Zero Point; Maximum machine table movement in the X direction (Extreme left position) and Y direction (Extreme forward position).

Setup Point: Left front corner of part in setup position. If machine controller will allow, this point can be used as X=0 and Y=0.

REVIEW EXERCISE #1

ANALYZE PART, FIXTURE AND SETUP POINT

1. The fourth step in basic programming is _____ _____ _____.
2. The final step in basic programming is to _____ _____ _____.
3. The drill size for the two tapped holes in the sample part is _____.
4. The material having the highest suggested cutting rate is _____.
5. The minimum suggested cutting rate for reaming (sfm) magnesium is _____.
6. The spindle rpm for drilling a 1/2" hole in aluminum should be _____.
7. The maximum drilling feed rate (ipm) for drilling a 1/2" hole in soft cast iron should be _____.
8. The lead of a 3/4" - 10 tap would be _____.
9. The drill size for a 1" - 8 would be _____.
10. When machining through the part, _____ _____ should be used under the part.
11. The setup point is usually located at the lower _____ corner of the part.

INTERMEDIATE OBJECTIVE

3. Calculate R and Z depths

LEARNING STEPS (Activities)

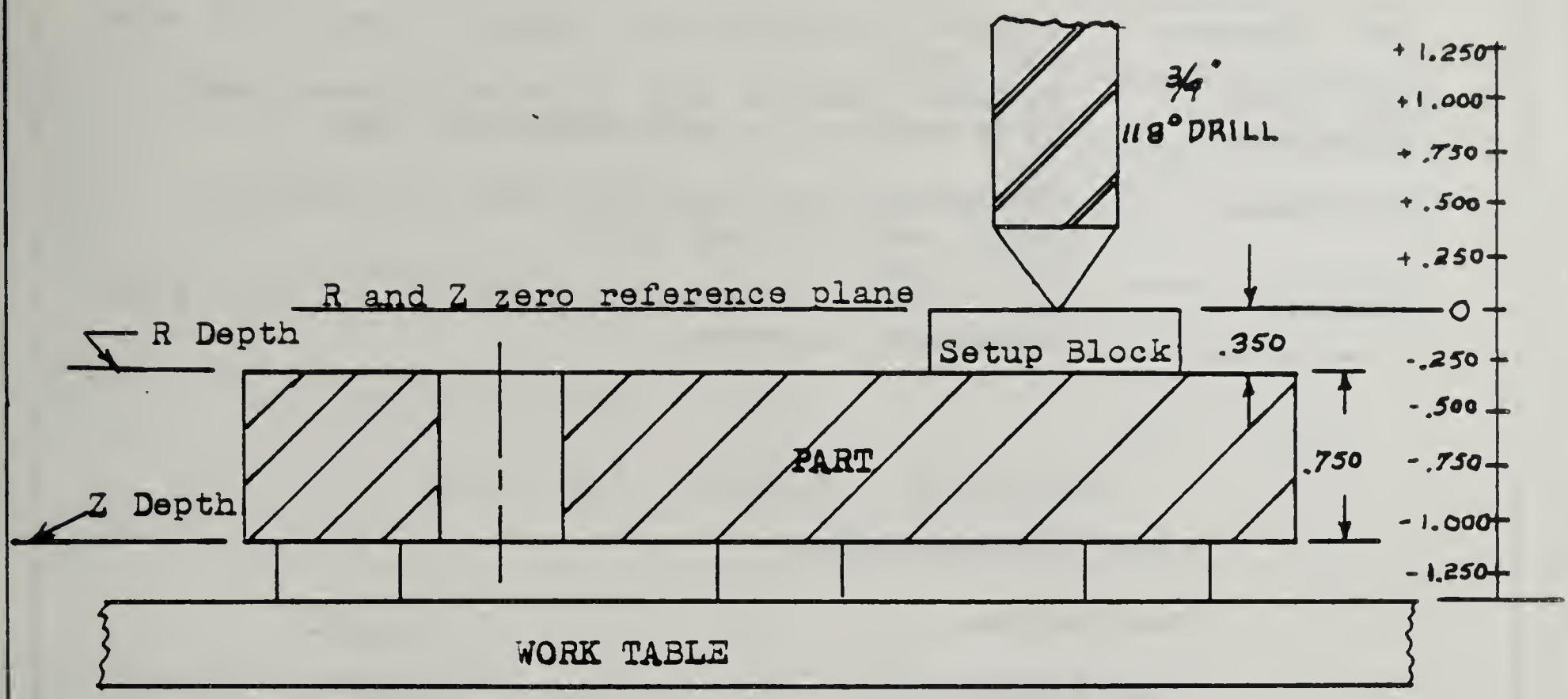
1. Use resource #1 to determine tool clearance, drill point allowance and overtravel.
2. Calculate the R and Z depths - see resource #2.
3. Complete procedure sheet identified in resource #3 and list your R and Z depth calculations.
4. Check your answers against solution sheet in resource #4.
5. Go to next intermediate objective listed in resource #5.

RESOURCES

1. Information sheet #2, page 5 and Information sheets #9 & 10, pages 15 & 16 in this learning guide.
2. Same as resource #1.
3. Procedure sheet #1, page 17 in this learning guide.
4. Solution sheet for procedure #1, page 27 in this learning guide.
5. Intermediate objective #4, page 18 in this learning guide.

INFORMATION SHEET # 9

R AND Z DEPTHS



INFORMATION SHEET #10

CALCULATING R AND Z DEPTHS

R depth:	Distance tool travels in rapid traverse to part surface (just before it contacts part surface).
Tool clearance:	A standard distance above the part, usually .100 inches.
Drill point allowance:	Allowance which is equal to the drill point length. It is equal to the drill diameter x .300.
Overtravel:	Distance the tool must travel past the surface to make a smooth through hole.
Z depth:	Part surface Z coordinate + depth of cut + drill point allowance + overtravel.

R Depth

R and Z reference plane	=	-.350
Tool clearance	=	+.100
Total R depth	=	-.250

Z Depth

Part surface Z coordinate	=	.350
Depth of cut	=	.750
Drill point allowance (.300 x .750)	=	.225
Overtravel	=	.100
Total Z depth	=	1.425

PROCEDURE SHEET #1

CALCULATING R AND Z DEPTHS

1. Tool clearance — Holes A & B _____
   Holes C & D _____
2. Drill point allowance — Holes A & B _____
   Holes C & D _____
3. Overtravel — Holes A & B _____
   Holes C & D _____
4. Calculate R depth

Holes A & B	Holes C & D
R = _____	R = _____

5. Calculate Z depth

Holes A & B	Holes C & D
Z = _____	Z = _____

Note: Review information sheets #2, 9 & 10 on pages 5, 15 & 16 in this learning guide to determine your answers.

INTERMEDIATE OBJECTIVE

4. Develop NC program operations steps

LEARNING STEPS (Activities)

1. Using resource #1, complete the heading and tooling portion (marked with X) on the NC Programming Form.
2. Using resource #2, list all process steps in the 'operation' column on the NC Programming Form and list the remainder of the operations required in producing a piece part. The first six operations are shown on the programming form.
3. Use resource #3 to check your operation sequence placed on the programming form.
4. Enter all appropriate data in the 'remarks' column on the NC Programming Form identified in resource #4. The first five remarks are shown on the programming form.
5. Check your work with the answer sheet identified in resource #5.
6. Go to next intermediate objective listed in resource #6.

RESOURCES

1. Information sheet #11, page 19 - NC Programming Form - in this learning guide.
2. Information sheet #11 - same as above
3. Answer sheet - NC Programming Form - Operation, page 28 in this learning guide.
4. Information sheet #11 - same as above
5. Answer sheet - NC Programming Form - Remarks, page 29 in this learning guide.
6. Intermediate objective #5, page 20 in this learning guide.

LAKE COUNTY AREA VOCATIONAL CENTER

NUMERICAL CONTROL PROGRAMMING FORM

TOOLING

Tool No.	Description	Speed(rpm)	Feed(ipm)
1.			
2.			
3.			
4.			
5.			

Part No.	Op. No.	Machine:	Fixture No.	Page_____of Page_____
Part	Material:	Dimensions:	Date:	By:

Operation	Seq. No.	Prep. Func.	X Position	Y Position	Z Position	I Position	J Position	K Position	Misc. Func.	Speed rpm	Feed ipm	Tool No.	Remarks
Start													Clear Memory
Clamp part													Fixture
Rapid to Hole A													From Fixed Zero
Rapid to part surface													R Depth
Drill Hole A													Z Depth
Retract Hole A													

Program	Task	Page
48.0503	032	19

INTERMEDIATE OBJECTIVE

5. Develop an NC program

LEARNING STEPS (Activities)

1. Review the programming code functions identified in resource #1.

2. Using the part print, fill in the following information blocks on the NC Programming Form:
   a. Seq. No.
   b. Prep. Func.
   c. X, Y & Z Positions
   d. Misc. Func.
   e. Speed rpm & Feed ipm
   f. Tool No.

   Use codes given in resource #2 for assistance

3. Proofread the program for accuracy using resource #3.

4. Submit the NC program to your instructor for evaluation of work completed. See resource #4.

5. Complete resource #5 to check your understanding of the terminal performance objective and to measure your ability to write a numerical control program for drilling and tapping operations.

RESOURCES

1. Information sheets #12, 13, 14 & 15, pages 21, 22, 23 & 24 in this learning guide.

2. Information sheet #2, Part Print, on page 5 in this learning guide
   and
   Information sheet #11, NC Programming Form, on page 19 in this learning guide
   and
   Information sheets #12, 13, 14 & 15 on pages 21, 22, 23 & 24 in this learning guide

3. Same as resource #1 above

4. Instructor's NC program solution sheet, pages 30 & 31 in this learning guide.

5. Performance/Product Checklist, page 25 of this learning guide.

EIA and AIA National Codes

PREPARATORY FUNCTIONS

G Word	Explanation
G00	Used for denoting a rapid traverse rate with point-to-point positioning.
G01	Used to describe linear interpolation blocks and reserved for contouring.
G02, G03	Used with circular interpolation.
G04	A calculated time delay during which there is no machine motion (dwell).
G05, G07	Unassigned by the EIA. May be used at the discretion of the machine tool or system builder. Could also be standardized at a future date.
G06	Parabolic interpolation.
G08	Acceleration code. Causes the machine, assuming capability, to accelerate at a smooth exponential rate.
G09	Deceleration code. Causes the machine, assuming capability, to decelerate at a smooth exponential rate.
G10, G11, G12	Normally unassigned for CNC systems. Used with some hard-wired systems to express blocks of abnormal dimensions.
G13, G14, G15, G16	Used to direct the control system to operate on a particular set of axes.
G17, G18, G19	Used to identify, or select, a coordinate plane for such functions as circular interpolation or cutter compensation.
G20 through G32	Unassigned according to EIA standards; however, they may be assigned by the control system or machine tool builder.
G33, G34, G35	Modes selected for machines equipped with thread-cutting capabilities and generally referring to lathes. G33 is used when a constant lead is sought. G34 is used when a constantly increasing lead is required, and G35 is used to designate a constantly decreasing lead.

EIA AND AIA NATIONAL CODES (continued)

G36 through G39	Unassigned.
G40	A command which will terminate any cutter compensation.
G41	A code associated with cutter compensation in which the cutter is on the left side of the work surface, looking in the direction of the cutter motion.
G42	A code associated with cutter compensation in which the cutter is on the right side of the work surface.
G43 G44	Used with cutter offset to adjust for the difference between the actual and programmed cutter radii or diameters. G43 refers to an inside corner, and G44 refers to an outside corner.
G45 through G49	Unassigned.
G50 through G59	Reserved for adaptive control.
G60 through G69	Unassigned.
G70	Inch programming.
G71	Metric programming.
G72	Three-dimensional circular interpolation-CW.
G73	Three-dimensional circular interpolation-CCW.
G74	Cancel multiquadrant circular interpolation.
G75	Multiquadrant circular interpolation.
G76 through G79	Unassigned.
G80	Cancel cycle.
G81	Drill, or spotdrill, cycle.
G82	Drill with a dwell.
G83	Intermittent, or deep-hole, drilling.
G84	Tapping cycle.
G85 through G89	Boring cycles.
G90	Absolute input. Input data is to be in absolute dimensional form.
G91	Incremental input. Input data is to be in incremental form.
G92	Preload registers to desired values. An example would be to preload axis position registers.
G93	Inverse time feed rate.
G94	Inches (millimetres) per minute feed rate.
G95	Inches (millimetres) per revolution feed rate.
G97	Spindle speed in revolutions per minute.

EIA AND AIA NATIONAL CODES (continued)

G98, G99	Unassigned.

MISCELLANEOUS FUNCTIONS

M Word	Explanation
M00	Program stop. Operator must cycle start in order to continue with the remainder of the program.
M01	Optional stop. Acted upon only when the operator has previously signaled for this command by pushing a button. When the control system senses the M01 code, machine will automatically stop.
M02	End of program. Stops the machine after completion of all commands in the block. May include rewinding of tape.
M30	End of tape command. Will rewind the tape and automatically transfer to a second tape reader if incorporated in the control system.
M03	Start spindle rotation in a clockwise direction.
M04	Start spindle rotation in a counterclockwise direction.
M05	Spindle stop.
M06	Command to execute the change of a tool (or tools) manually or automatically.
M07	Turn coolant on (flood).
M08	Turn coolant on (mist).
M09	Coolant off.
M10, M11	Automatic clamping of the machine slides, workpiece, fixture, spindle, etc. M11 is an unclamping code.
M12	An inhibiting code to synchronize multiple sets of axes, such as a four-axis lathe having two independently operated heads or slides.
M13	Combines simultaneous clockwise spindle motion and coolant on.
M14	Combines simultaneous counterclockwise spindle motion and coolant on.
M15, M16	Rapid traverse or feed motion in either the +(M15) or –(M16) direction.
M17, M18	Unassigned.
M19	Oriented spindle stop. Spindle stop at a predetermined angular position.
M20 through M29	Unassigned.
M31	A command known as interlock bypass for temporarily circumventing a normally provided interlock.
M32 through M39	Unassigned.
M40 through M46	Used to signal gear changes if required at the machine; otherwise, unassigned.

EIA AND AIA NATIONAL CODES (continued)

M47	Continues program execution from the start of the program unless inhibited by an interlock signal.
M48	Cancel M49.
M49	A function that deactivates a manual spindle or feed override and returns to the programmed value.
M50 through M57	Unassigned.
M58	Cancel M59.
M59	A function which holds the RPM constant at its value when M59 is initiated.
M60 through M99	Unassigned.

OTHER ADDRESS CHARACTERS

Address Character	Explanation
A	Angular dimension about the X axis.
B	Angular dimension about the Y axis.
C	Angular dimension about the Z axis.
D	Can be used for an angular dimension around a special axis, for a third feed function or for tool offset.
E	Used for angular dimension around a special axis or for a second feed function.
H	Unassigned.
I, J, K	Used with circular interpolation.
L	Not used.
O	Used in place of the customary sequence number word address N.
P	A third rapid traverse code or tertiary motion dimension parallel to the X axis.
Q	Second rapid traverse code or tertiary motion dimension parallel to the Y axis.
R	First rapid traverse code or tertiary motion dimension parallel to the Z axis or the radius for constant surface speed calculation.
U	Secondary motion dimension parallel to the X axis.
V	Secondary motion dimension parallel to the Y axis.
W	Secondary motion dimension parallel to the Z axis.

PERFORMANCE/PRODUCT CHECKLIST

Program: Machine Shop

Task No: 032 - Write a numerical control program for drilling and tapping operations

Student's Name: _____ Date Of Attempt: _____

Evaluator's Name: _____ Evaluation Site: _____

Performance Attempt: 1 2 3 4

Terminal Performance Objective:

Given the necessary information, supplies and equipment, you will write a numerical control program for drilling and tapping operations. To master this task you must score 80 out of 106 points to score 77% on a programming form.

Directions To The Student:

Before attempting this task for mastery, carefully review this checklist. You will be evaluated on the basis of this checklist. When you feel you are ready for evaluation, contact your instructor. You must complete your performance within 30 minutes and must score at least 80 out of 106 points or 77 % for mastery. Critical items are marked with an asterisk (*). These items must be satisfactorily completed.

Directions To The Evaluator:

The student will contact you when ready for the evaluation. The student must complete the performance within _____ minutes and must score _____ out of _____ points or _____ % and all items marked with an asterisk (*) must be satisfactorily completed.

ANSWER SHEET - REVIEW EXERCISE #1

1. sequence of operations
2. edit and debug
3. "I"
4. magnesium
5. 150 sfm
6. 2000 rpm
7. 1.750 ipm
8. .100 inch
9. 7/8 inch
10. spacer blocks
11. left

SOLUTION SHEET - PROCEDURE #1

CALCULATING R AND Z DEPTHS

1. Tool clearance — Holes A & B (-.750 + .100) = -.650
   Holes C & D (-.250 + .100) = -1.500

2. Drill point allowance — Holes A & B -.113
   Holes C & D -.080

3. Overtravel — Holes A & B -.100
   Holes C & D zero

4. Calculate R depth

Holes A & B

R & Z reference plane	=	-.250
Offset amount	=	-.500
Tool clearance	=	+.100
R depth	-	-.650

R = -.650

Holes C & D

R & Z reference plane	=	-.250
Tool clearance	=	+.100
R depth	=	-.150

R = -.150

5. Calculate Z depth

Holes A & B

Part surface Z coordinate	=	- .750
Depth of cut	=	-1.500
Drill point allowance	=	- .113
Overtravel	=	- .100
Z depth	=	-2.463

Z = -2.463

Holes C & D

Part surface Z coordinate	=	- .250
Depth of cut(.750 + .250)	=	-1.000
Drill point allowance	=	- .080
Z depth	=	-1.330

Z = -1.330

ANSWER SHEET - NC PROGRAMMING FORM - OPERATION

N000	Start
N001	Clamp part
N002	Rapid to Hole A
N003	Rapid to part surface
N004	Drill Hole A
N005	Retract Hole A
N006	Rapid to Hole B
N007	Rapid to part surface
N008	Drill Hole B
N009	Retract Hole B
N010	Rapid to Hole C
N011	Rapid to part surface
N012	Drill Hole C
N013	Retract Hole C
N014	Rapid to Hole D
N015	Rapid to part surface
N016	Drill Hole D
N017	Retract Hole D
N018	Tap Hole D
N019	Retract Hole D
N020	Rapid to Hole C
N021	Tap Hole C
N022	Retract Hole C
N023	Rapid to zero
N024	Stop
N025	Unclamp part

End of program

ANSWER SHEET - NC PROGRAMMING FORM - REMARKS

N000	Clear Memory
N001	Fixture
N002	From fixed zero
N003	R depth
N004	Z depth
N005	
N006	From fixed zero
N007	R depth
N008	Z depth
N009	Tool change
N010	Letter "I" drill
N011	R depth
N012	Z depth
N013	
N014	From fixed zero
N015	
N016	
N017	Tool change
N018	5/16-24 tap
N019	
N020	From fixed zero
N021	5/16-24 tap
N022	
N023	Fixed zero
N024	
N025	End of program

SOLUTION SHEET - N.C. PROGRAM

LAKE COUNTY AREA VOCATIONAL CENTER

NUMERICAL CONTROL PROGRAMMING FORM

TOOLING

Tool No.	Description	Speed(rpm)	Feed(ipm)
1.	3/8 (.375) Drill	750	3.[illegible]
2.	"I" (.266) Drill	1050	4.20
3.	5/16 - 24 - UNF Tap	112	4.67
4.			
5.			

Part No. 7451 | Op. No. | Machine: Vert. Mill | Fixture No. | Page 1 of Page 2

Part Slide Bracket | Material: ASA 1030 | Dimensions: Inches | Date: | By:

Operation	Seq. No.	Prep. Func.	X Position	Y Position	Z Position	I Position	J Position	K Position	Misc. Func.	Speed rpm	Feed ipm	Tool No.	Remarks
Start	000												Clear Memory
Clamp Part	001								M10				Fixture
Rapid to Hole A	002	G00	40000	3.750	1.5000							1	Set Z to Zero
Rapid to Part Surface	003				-.06500								R Depth
Drill Hole A	004	G81			-.17130				M03	750	3.00		Z Depth
Retract Hole A	005				00000				M05				
Rapid to Hole B	006	G00		57500									From Fixed Zer
Rapid to Part Surface	007				-06500							1	R Depth
Drill Hole B	008	G81			-17130				M03	750	3.00		Z Depth
Retract Hole B	009				00000				M05				Tool Change
Rapid to Hole C	010	G00	72500	60000								2	Letter "I" Drill
Rapid to Part Surface	011			-01500									R Depth
Drill Hole C	012	G81			-13300				M03	1050	4.20		Z Depth
Retract Hole C	013				00000				M05				
Rapid to Hole D	014	G00		35000								2	From Fixed Ze
Rapid to Part Surface	015				-01500								
Drill Hole D	016	G81			-13300				M03	1050	4.20		
Retract Hole D	017				00000				M05				Tool Change
Tap Hole D	018	G84			-10000				M03	112	4.67	3	5/16 - UNF Tap
Retract Hole D	019				00000				M04				
					(Continued)								

SOLUTION SHEET - N.C. PROGRAM (Continued)

LAKE COUNTY AREA VOCATIONAL CENTER

NUMERICAL CONTROL PROGRAMMING FORM

TOOLING

Tool No.	Description	Speed(rpm)	Feed(ipm)
1.	3/8 (.375) Drill	750	3.00
2.	"I" (.266) Drill	1050	4.20
3.	5/16 - 24 - UNF Tap	112	4.67
4.			
5.			

Part No. 7451 | Op. No. | Machine: Vert. Mill | Fixture No. | Page 2 of Page 2

Part Slide Bracket | Material: ASA 1030 | Dimensions: Inches | Date: | By:

Operation	Seq. No.	Prep. Func.	X Position	Y Position	Z Position	I Position	J Position	K Position	Misc. Func.	Speed rpm	Feed ipm	Tool No.	Remarks
Rapid to Hole C	020	G00		60000					M05				
Tap Hole C	021	G84			-10000				M03	112	4.67		5/16-24 Tap
Retract Hole C	022				00000				M04				
Rapid to Zero	023	G00	00000	00000					M05				Fixed Zero
Stop	024								M02				
Unclamp Part	025								M11				End of Program

Program	Task	Page
MS 0503	032	31

LCAVC

LAKE
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COMPETENCY-BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

STUDENT LEARNING GUIDE

Draft COPY

Produced By W. Pooler Date 3/4/85

TASK: Tape and punch N.C. program. Dry run program and perform machining operations.

PURPOSE:

This guide will expose the student to the steps used in operating the controls of the Tarco milling machine. It will also give students practice in taping and punching an N.C. program. The student will then go to the milling machine to perform the programmed operations.

Program	Task	Est.Time	Prereq.
48.0500	033	[illegible]	[illegible]

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME _____ SOCIAL SECURITY NUMBER _____

LENGTH OF CONTRACT (NORMAL TIME IN HOURS) _____

2. TERMINAL PERFORMANCE OBJECTIVE

Given: N.C. program from task 032, Terco milling machine, tools and performance exam.

You Will: Simplify, tape and punch CNC program and perform programmed operations.

How Well: To master this task you must score 80 out 100 or score 80% on the performance check list.

2a. INTERMEDIATE OBJECTIVE(s)

1. Simplify CNC program from task 032.
2. Tape and punch CNC program. Dry run program on milling machine.
3. Locate and clamp project on milling machine table.
4. Drill holes A and B.
5. Drill holes C and D.
6. Tap holes C and D.

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____. I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

Student's Signature _____

Instructor's Signature (verifies competency) _____

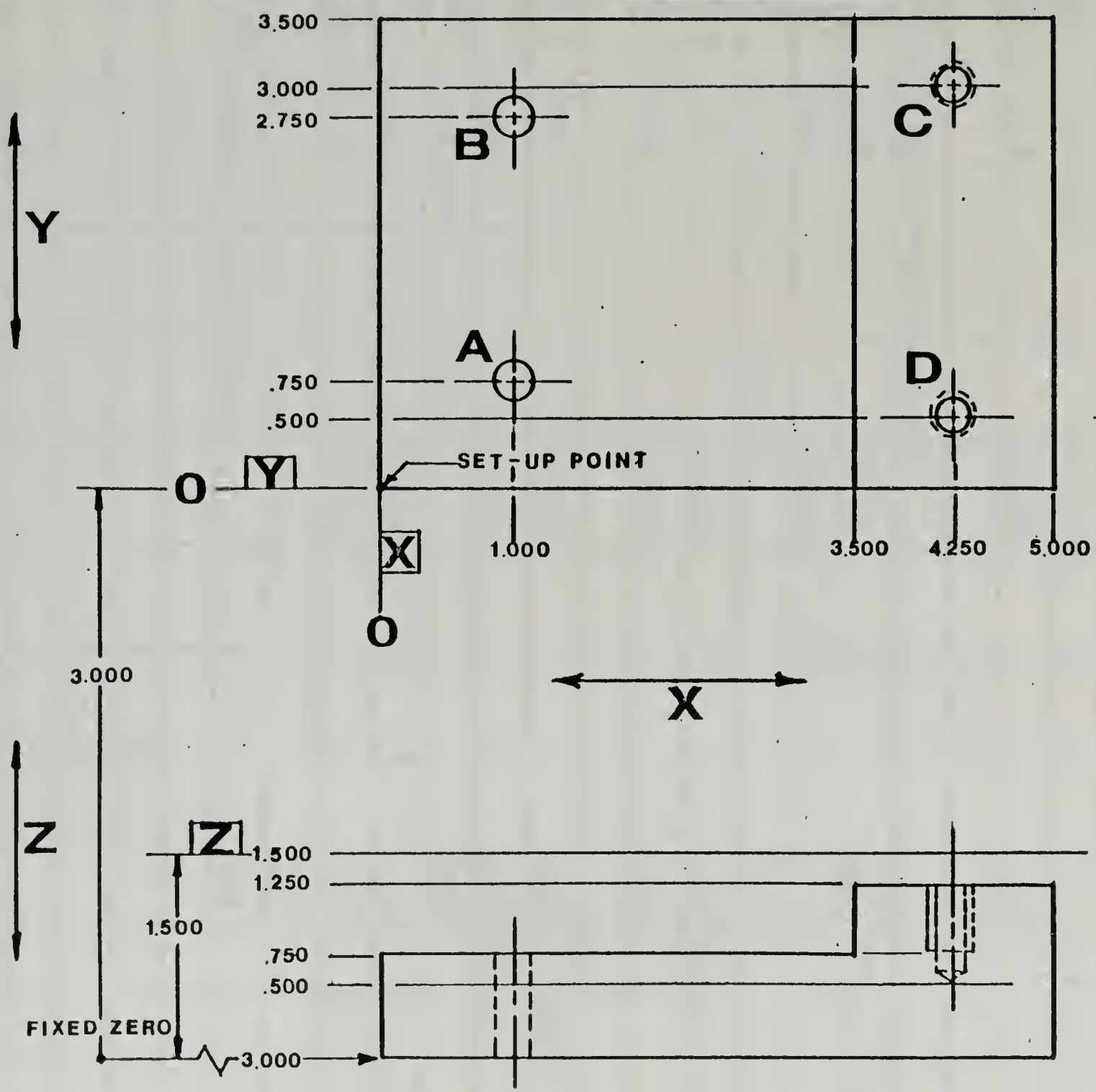
Program	Task	Page
48.0503	033	2

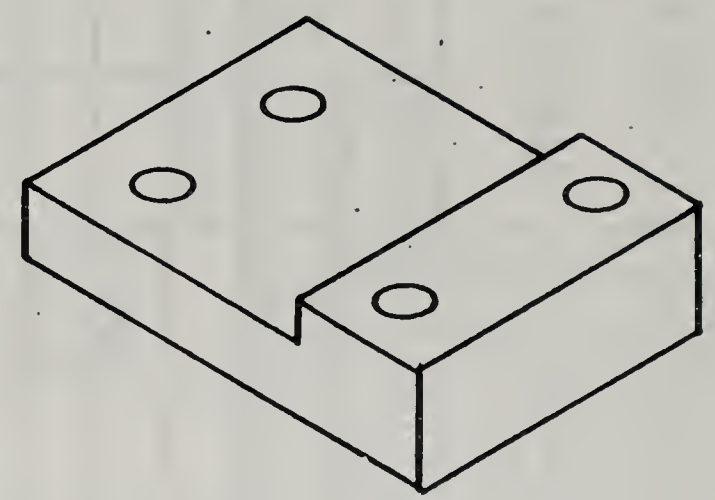
INTERMEDIATE OBJECTIVE

I Simplify CNC program from task 032

LEARNING STEPS (Activities)	RESOURCES
1. Using CNC program from task 032, list tooling on programming form. Notice that a 10-1 speed reduction tapping chuck has been added as tool No. 3.	1. Pages 30 and 31 from task 032 and information sheet #1 and #2 Pages 4 and 5 in this learning guide
2. Calculate the speeds and feeds for the drilling and tapping operations. Use the lowest cutting rate for aluminum.	2. Information sheet #3 and #4 pages 6 and 7 in this learning guide
3. Complete each block on the program sheet. List only tool movements and machining operations. Use print set-up as X, Y and Z as fixed zero. Use G, M, S and F codes from page 7 and 8 in Terco manual	3. Information sheet #1, page 5 in this learning guide. Terco manual
4. Go to next intermediate objective.	4. Intermediate objective #2, page 8 in this learning guide.

Information Sheet #1





SIZE SYMBOL	A	B	C	D
HOLE DIA.	.375	.375	.266	.266
TAP SIZE			5/16	5/16
			24 UNF	24 UNF

TOLERANCES	TITLE SLIDE BRACKET		
DECIMAL ±	MATERIAL Aluminum 2024	SCALE	DRAWN BY: / APPROVED BY:
FRACTIONAL ±	CO. NAME		
ANGULAR ±	DATE 25/10/84	DRAWING NUMBER 7451	

Information sheet #2

LAKE COUNTY AREA VOCATIONAL CENTER

NUMERICAL CONTROL PROGRAMMING FORM

TOOLING

Tool No.	Description	Speed(rpm)	Feed(ipm)
1.	3/8 (.375) Drill		
2.	"I" (.266) Drill		
3.	Tapping chuck - 10-1 reduction		
4.	5/16-24-UNF Tap		
5.			

Part No. 7451 | Op. No. | Machine: Vert Mill | Fixture No. | Page 1 of Page 1

Part Slide Bracket | Material: Aluminum 2024 | Dimensions: Inches | Date: | By:

Operation	Seq. No.	Prep. Func.	X Position	Y Position	Z Position	I Position	J Position	K Position	Misc. Func.	Speed rpm	Feed ipm	Tool No.	Remarks
Rapid to Hole A	001	G00	10000	07500									
Drill Hole A	002	G81			-1510				03	S9	10	1	Z Depth
Retract Drill	003				00000								
Rapid to Hole B	004	G00		27500					05				
Drill Hole B	005	G81			-1510				03	S9	10	1	Z Depth
Retract Drill	006				00000				05				Tool change
Rapid to Hole C	007	G00	42500	30000									
Drill Hole C	008				-10000				03	S9	10	2	Z Depth
Retract Drill	009				00000								
Rapid to Hole D	010	G00		05000					05				
Drill Hole D	011				-10000				03	S9	10	2	Z Depth
Retract Drill	012				60000				05				Tool change
Tap Hole D	013				-07500				03	S1	2.08	4	Z Depth
Retract Tap	014				20000				04	S1	2.08		
Rapid to Hole C	015	G00		30000					05				
Tap Hole C	016				-07500				03	S1	2.08	4	Z Depth
Retract Tap	017				20000				04	S1	2.08		
									05				
Rapid to Zero	018	G00	00000	00000					02				
Stop	019								06				End of Program

Program | Task | Page

~~PROCEDURE SHEET~~

Information Sheet #3

Page #6 from task 032

Program	Task	Page
18.0503	033	6

~~PROCEDURE SHEET~~

Information Sheet #4

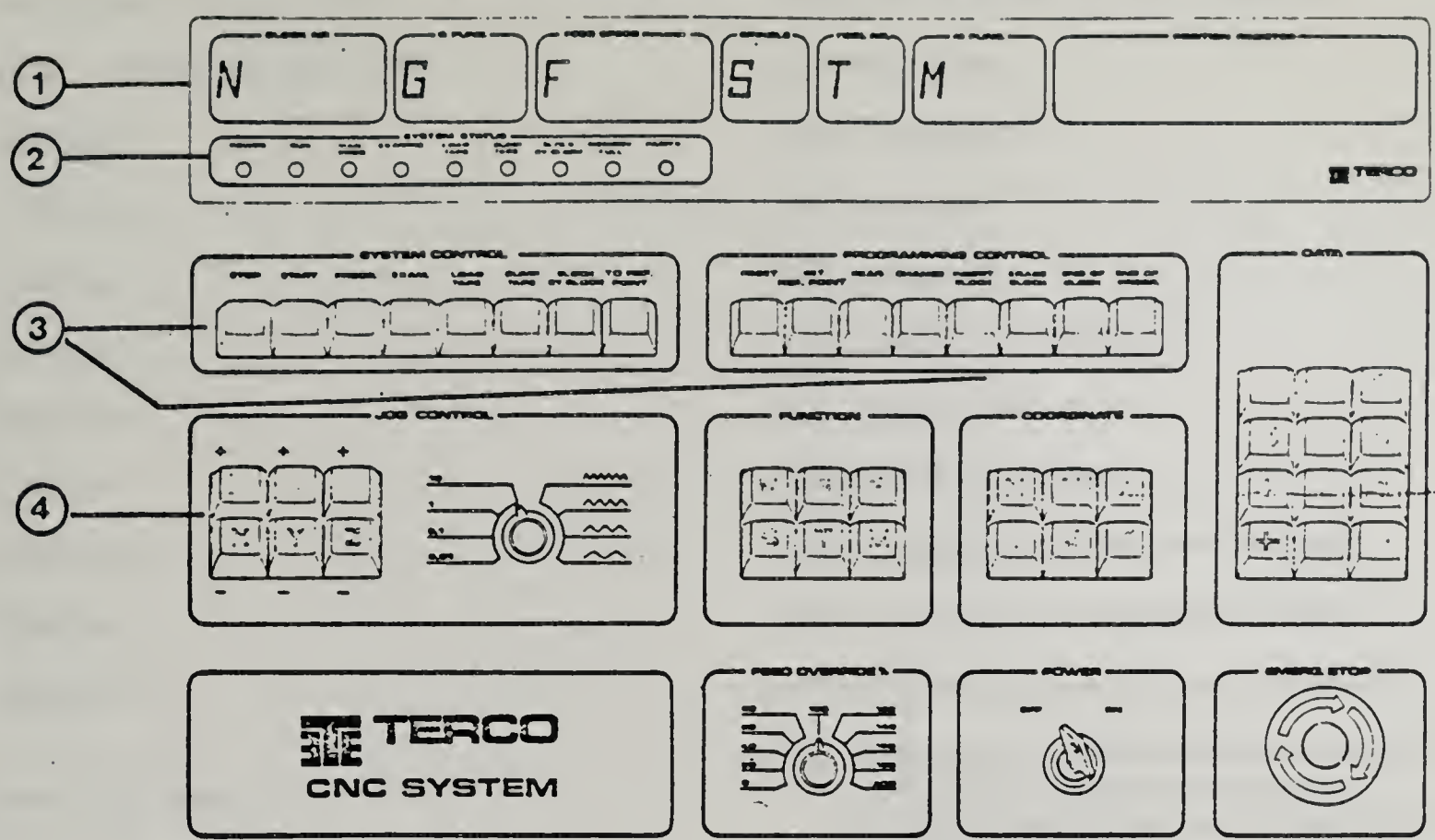
page 7 in task #032

Program	Task	Page
98.0504	032	7

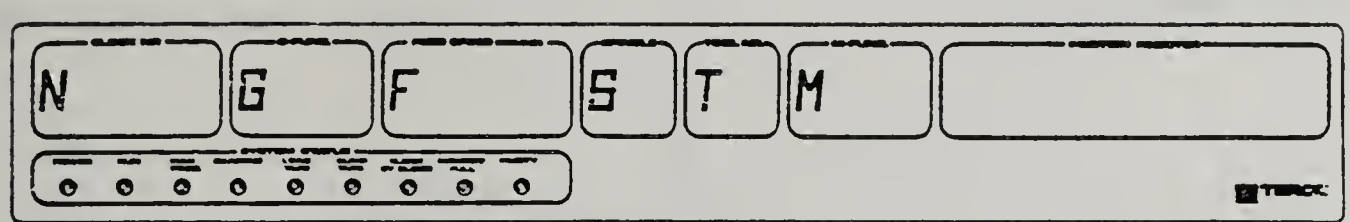
INTERMEDIATE OBJECTIVE

2. Tape and punch CNC program.
Dry run program on milling machine.

LEARNING STEPS (Activities)	RESOURCES
1. Examine Terco equipment controls.	1. Review Terco vidio tape and information sheets #5-#9, pages 9-13 in this learning guide.
2. Record CNC program on Terco programming station	2. Review Terco programming station instruction manual. Completed CNC program, page 5 in this learning guide.
3. Proof-read displayed CNC program	3. Displays on Terco programming station and CNC program, page 5 in this learning guide
4. Punch CNC program tape.	4. Terco CNC Tape punch machine.
5. Dry run CNC program. (Have instructor check)	5. Terco CNC program station, Terco milling machine and CNC program, page 5 in this learning guide.
6. Go to next intermediate objective.	6. Intermediate objective #3, page 14 in this learning guide.



1. Functions



N 000 – 999 BLOCK NUMBER. For block numbers under 100, the zero or zeros before the figure must first be keyed in.
Block numbers 901–909 are reserved for tool radius compensation.

G 00 – 99 GENERAL FUNCTIONS i.e. stating how movement of the milling tool shall take place.

G 00 High speed 500 mm/min, positioning. (Point to Point)

G 01 (Linear control) Linear interpolation.

G 02 (Circular control clockwise) Circular interpolation clockwise.

G 03 (Circular control counter-clockwise) Circular interpolation counter-clockwise.

G 04 Delay in J seconds.

G 12 Hole milling clockwise (radius given in I).

G 13 Hole milling counter-clockwise (radius given in I).

G 17 Selecting of operating plane XY.

G 18 Selecting of operating plane XZ.

G 19 Selecting of operating plane YZ.

G 25 Jump to another blocknumber (for double jump see Ex. 8).

G 40 Cancel tool radius compensation.

G 41 Tool radius compensation left.

G 42 Tool radius compensation right.

G 53 Return to previously programmed ref.point.

G 58 Change of ref. point.

G 73 Drilling cycle with "step-feeding", step of J mm with 1 mm return to clear cuttings.

G 81 Drilling cycle with delay of J seconds in the lowest position, return with fast feed to Z0.

G 82 Drilling cycle with fixed delay of 0.5 seconds in the lowest position, return with fast feed to Z0.

G 83 Drilling cycle with "step-feeding", step of J mm with return to Z0.

Information Sheet = 6

F	0–250 mm/min. FEED SPEED.
S	0–9 SPINDLE SPEED in rpm.
S1	500 rpm
S2	750 rpm
S3	1000 rpm
S4	1250 rpm
S5	1500 rpm
S6	1750 rpm
S7	2000 rpm
S8	2250 rpm
S9	2500 rpm
T	0–9 TOOL NUMBER
M	00–99 MISCELLANEOUS FUNCTIONS
M02	End of program with return to ref. point.
M03	Spindle rotation – Clockwise.
M04	Spindle rotation – counter-clockwise.*
M05	Spindle stop.
M06	Program stop.
M08	Coolant on.*
M09	Coolant off.*
M10	Clamping off workpiece.
M11	Release of workpiece.
M60	Change of workpiece.
M96	Circular track compensation ON (G41)
M97	Circular track compensation OFF (G42)
XYZ	Programmable length 000.00 ± 999.99 mm
IJK	Positioning of circle centre with reference to the start point during circular interpolation. The start point goes out from a coordinate system IJK where I lies in the X axis, J in the Y axis and K in the Z axis.

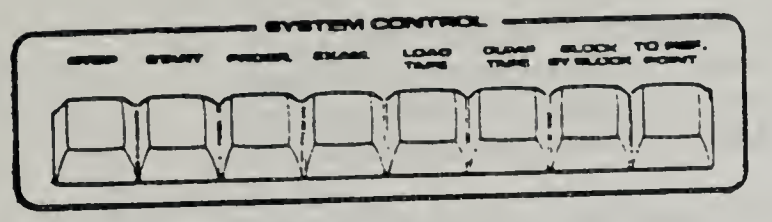
* For Milling machine CNC 4430 only.

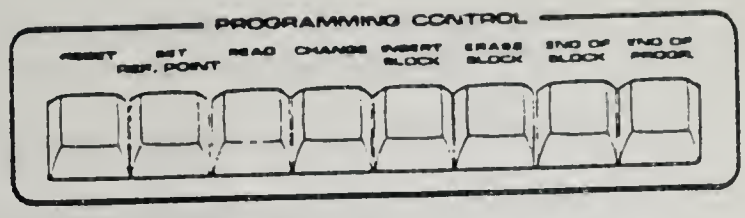
2. Control Lamps

POWER:	Indicates that power is available.
RUN:	Indicates that the program is running.
MAN PROG.:	Manual programming.
EXAMINE:	Indicates when an examination of the program is in progress.
LOAD TAPE:	Feeding in of program from punched tape or cassette.
DUMP TAPE:	Feeding out program for recording by punched tape, cassette or printer.
BLOCK BY BLOCK:	Program is run one block at a time.
MEMORY FULL:	Capacity of the memory bank is full.
PARITY:	If an odd number of holes are registered in any parallel row, the feeding into the memory will stop.

Information Sheet #7

3. System Control and Programming Control.





STOP: Stops the program. Restart by pressing START without specifying block number.

START: Complete the program after the block number has been specified.

PROGR.: For manual programming.

EXAMINE: Followed by the block number which is to be examined.

LOAD TAPE: For feeding in of program to the memory from punched tape or cassette. Proceed as follows:

Punched Tape:

1. Ensure that the leads with CANON plugs are connected between the control unit and the tape reader CNC 4423.
2. Switch the power ON for the control unit and for tape reader.
3. Remove perspex cover protecting the 4 small switches and switch them as follows.
   Left hand switch to HDX.
   Two switches in the middle — not relevant.
   Right hand switch to HIGH SPEED.
4. Feed in tape making sure that the holes lie in the sprockets.
5. Switch upper left switch marked READER, on. An indicating lamp will light.
6. Press LOAD TAPE on the control unit.
7. Press button number 2 on the control unit.

When the program has been fed in, the LOAD TAPE indicating lamp goes out.

8. Switch off the tape reader.

Cassette

1. Ensure interconnecting leads with DIN plug and remote control jack plug, are connected.
2. Place cassette in the tape recorder CNC 4437 and run the tape to the beginning of the program.
3. Switch on PLAY button on tape recorder CNC 4437.
4. Press LOAD TAPE on the control unit.
5. Press button number 3 on the control unit.
   Cassette will start. Note: A program of 10 blocks will take approx. 3 secs.
   Load tape indicating lamp goes out when loading is complete, and cassette automatically stops.
6. Switch of tape recorder.

Information Sheet #8

DUMP TAPE: Recording of program on a punched tape or a cassette or writing out of program on a printer CNC 4445.

1. Switch on, tape punch, audiocassette or printer.
2. Set the printer to line or the audiocassette to record position.
3. Press DUMP TAPE on the keyboard and the DUMP TAPE indicating lamp lights.
   Press the start block number for the program and an indication will appear at the right hand side of the position register.
   Press button number 1 and the program will be dumped from the memory to the printer.
   Press button number 2 and the program will be dumped from the memory to the tape punch.
   Press button number 3 and the program will be dumped from the memory to the audiocassette.

BLOCK BY BLOCK: Excecutes the program one block at a time. To restart normal program, press START without specifying a block number.

TO REF. POINT: The spindle stops and the machine automatically returns to the reference point at fast feed rate, first in the Z axis and then in the X-Y axes.

RESET: Reset of the system. Only to be used in emergency.

SET REF POINT: Sets the reference point of the machine tool to that position it is currently in. In the case of the milling machine this reference point is the zero point.

READ: Selecting of the indicated coordinate.

CHANGE: For changing data in the retrieved block. Must be followed by END OF BLOCK.

INSERT BLOCK: Inserts a new block in the program in front of the block which is seen on the display. Must be followed by END OF BLOCK.

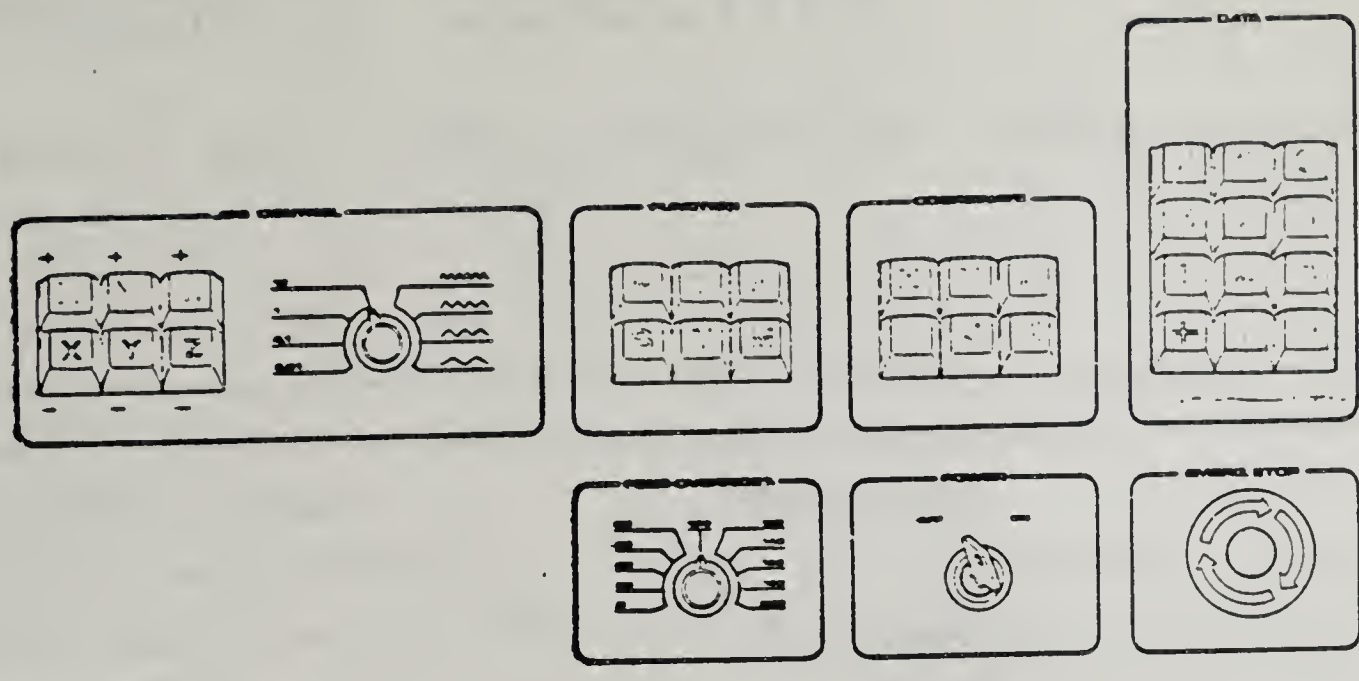
ERASE BLOCK: Removes the block which is presented on the display.

END OF BLOCK: Must be used after each programmed block. Also after CHANGE and INSERT.

END OF PROGR.: Used to conclude a complete program, or when editing is complete.

Information Sheet = ~~30~~ #9

Other controls



JOG CONTROL: The push buttons are used for manual running.
The speed is set by means of the knob to the right.
The desired distance 10, 1, 0.1 or 0.01 mm can also be preset.

The N, G, F, S, T and M functions: A function letter must be specified before the digital value for the respective function is keyed in.

Coordinates: For programming the X, Y and Z coordinates and for circular interpolation I, J and K.

Digit keys: When the coordinate direction has been selected, specify the desired travel (5 digits) here and a minus direction, if this is applicable. The positive direction need not be specified.
Note: All numbers must be specified, a comma is not required, e.g. 07655 means 76,55 mm.

CHANGING THE FEED RATE: The programmed feed rate can be changed manually from 0 % to 200 % in steps of 20 %.
Note: This can be carried out when the program is running. If the milling cutter is being lowered too quickly the feed speed can be reduced.
The feed override mentioned above cannot be used on G00 high speed positioning.

POWER SUPPLY: Key for switching on the power.

EMERGENCY STOP: When the emergency stop button is pressed all functions are switched off.

INTERMEDIATE OBJECTIVE

3. Locate and clamp project on milling machine table

LEARNING STEPS (Activities)	RESOURCES
1. Referring to resource #1, position and secure the Location fixture	1. Information sheet #~~11~~ 10 & 11 page ~~[illegible]~~ 15 + 16 in this guide
2. Using resource #2, locate and clamp project on milling machine table	2. Information sheet #~~8~~ 2 page 17 in this guide
3. Follow instructions in resource #1 to set X and Y reference point	3. Information sheet #10 page 15 in this guide
4. Go to next intermediate objective.	4. Intermediate objective #4 page 18 in this guide

Assembly of the fixture

The fixture consists of a set-square which has a hole for aligning the centring tool.

Run the table to its maximum in the X and Y axis so that the spindle is as far into the left corner as is possible.

Place the fixture and its fixing screw on the table. Do not fasten.

Insert the centring tool in the chuck and lower it into the hole in the set-square.

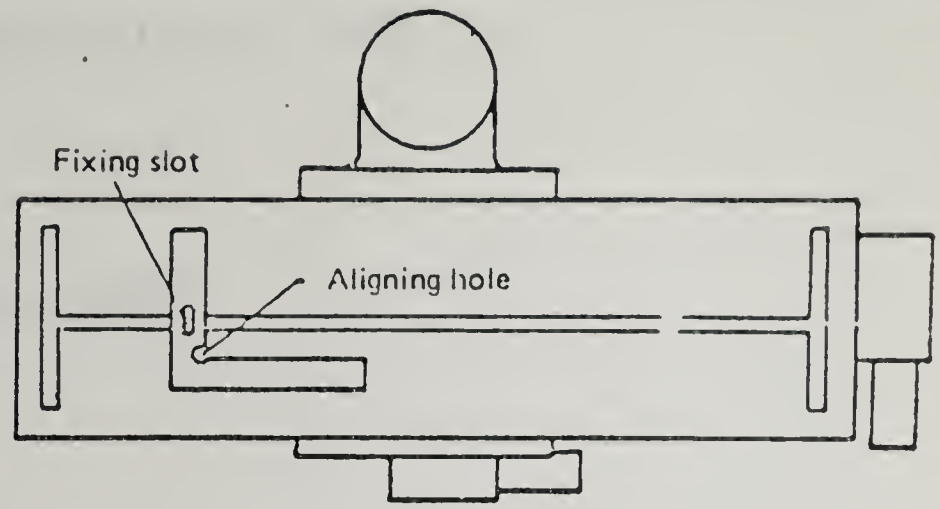
Square up the fixture using a second square, as shown in the diagram.

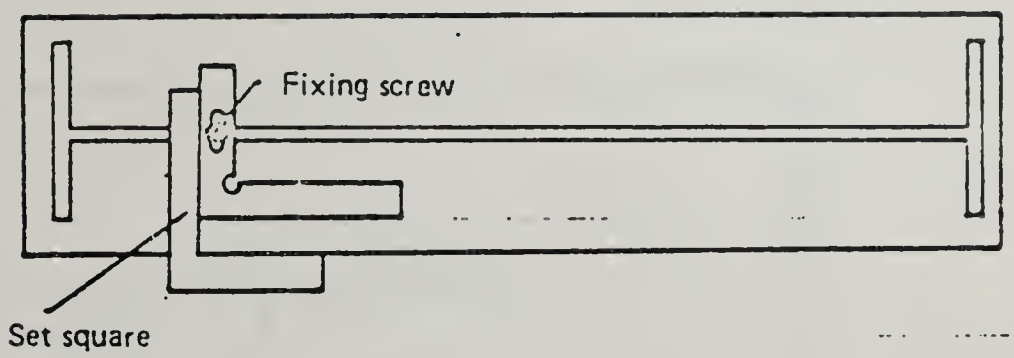
Tighten the fixture to the table.

Press the SET REF POINT button.

Remove the centring tool. Run manually in the +Z axis for easy removal.

The machine is now set for machining with drilling or milling cutters.





Fixture of tool cutter

Place a ~~5 mm~~ .200" milling cutter in the sleeve and tighten up the locking nut tightly.

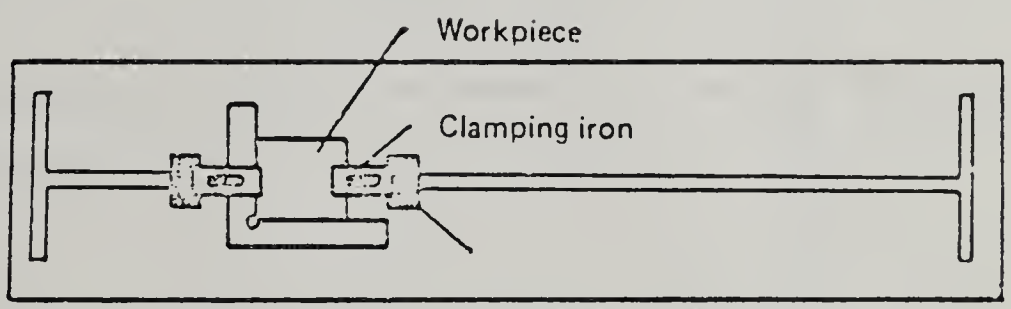
Raise the table and with the aid of a ~~10 mm~~ .400" aluminium plate check that the milling tool meets this plate evenly and precisely.

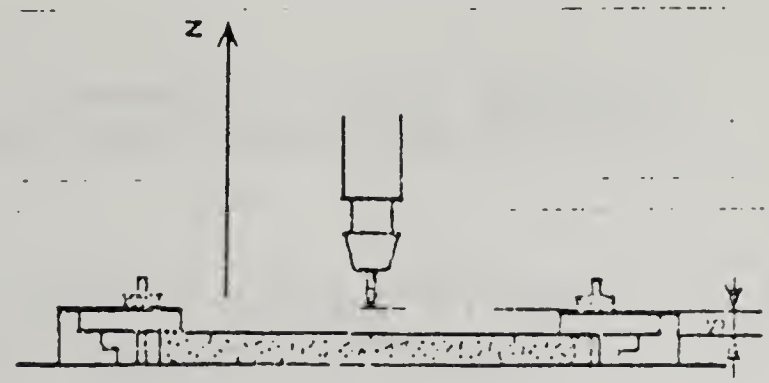
Press the SET REF POINT button.

Lower the table so that Z+00500 (+00.500) is indicated on the positioning register.

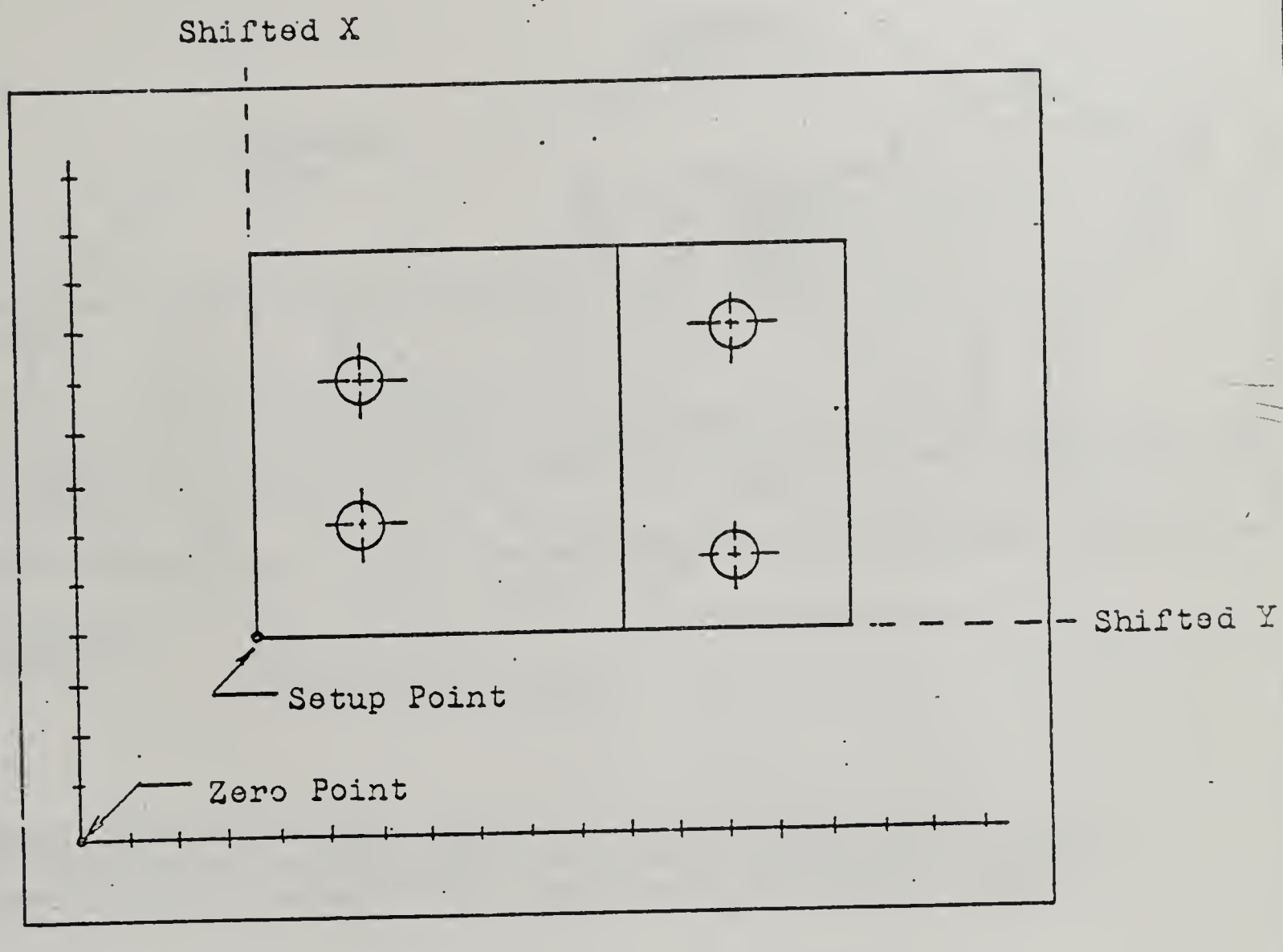
Press the SET REF POINT button for this new point.

The reference point is now 15 mm (.600") above the table in the Z axis.





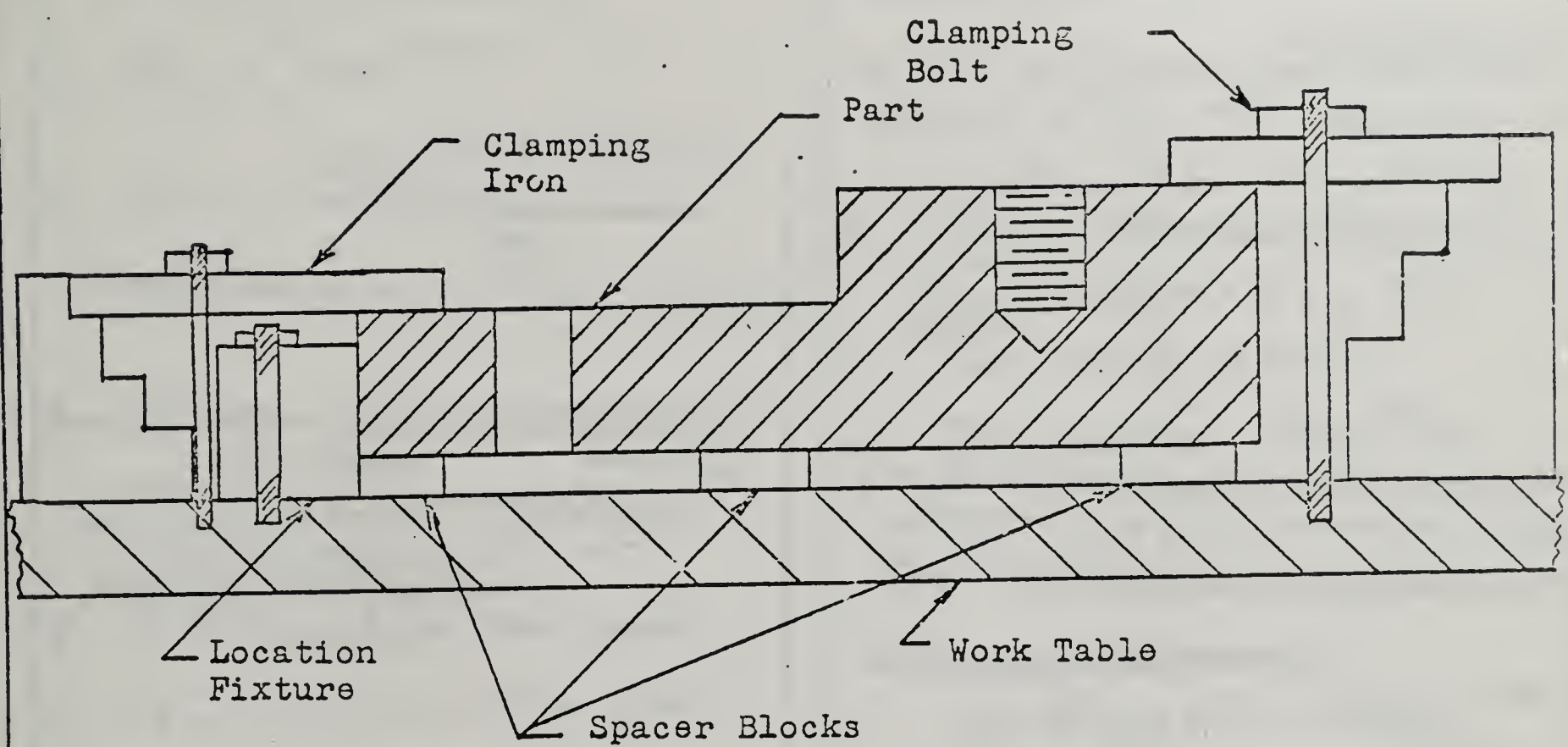
"0" and "Setup Point"



Zero Point; Maximum machine table movement in the X direction (Extreme left position) and Y direction (Extreme forward position).

Setup Point: Left front corner of part in setup position. If machine controller will allow, this point can be used as X=0 and Y=0.

Fixture and Clamping



Spacer blocks used for machine through clearance.
Spacer blocks not required for blind drilling or machining operations not penetrating completely through the part.

INTERMEDIATE OBJECTIVE

4. Drill holes A and B

LEARNING STEPS (Activities)	RESOURCES
1. Mount tool #1	1 C.N.C. program, ~~Tool 022~~ page 5 in this learning guide
2. Using .250 set-up block, ~~calculations from Task 022,~~ set #1 tool height.	2. Information sheet #13, ~~Page 7 program task 022~~ Page 19 in this learning guide.
~~3. Using resource #1 and N.C. program in task program~~	3. ~~N.C. program in task 022~~ Information sheet #10, page 15 in this learning guide.
3. Set z coordinate zero point	~~Task 022~~
4. Using resource #4, drill hole A and B	4. ~~Page 7 task 022~~ Information sheet #11 ~~Program~~ page 11 in this learning guide.
5. Using resource #5, turn off machine for first tool change	5. Same as above
6. Go to next intermediate objective	6. Intermediate objective #5 page #20 in this guide

Program	Task	Page
[illegible]	[illegible]	18

CRITICAL ITEMS	~~ITEMS TO BE OBSERVED OR CHECKED~~	RATING	
		YES	NO
	Information Sheet #13		
	page #15 from task 032		

TOTAL POINTS EARNED =

POINTS NEEDED FOR MASTERY =
TOTAL POINTS POSSIBLE =

Program	Task	Page
43.0503	032	14

INTERMEDIATE OBJECTIVE

5. Drill holes C and D

LEARNING STEPS (Activities)	RESOURCES
1. Remove Tool #1 and mount Tool #2, 1250 set-up block	1. Information sheet #2, ~~[illegible]~~ page 5 in this learning guide.
2. Using ~~calculations from task 032,~~ set #2 Tool height.	~~2. [illegible] from task 032.~~ 2. Information sheet #13, page 19 in this learning guide.
3. Set Z coordinate zero point	3. Information sheet #10, page 15 ~~[illegible]~~ in this learning guide
4. Drill holes C and D.	4. Information sheet #2, page 11 in this learning guide.
5. Using resource #4, turn off machine for second tool change.	5. Same as above.
6. Go to next intermediate objective.	6. Intermediate objective #6, page 21 in this guide.

Program	Task	Page
45 0503	033	20

INTERMEDIATE OBJECTIVE

5. Tap holes C and D

LEARNING STEPS (Activities)	RESOURCES
1. Remove tool #2, replace drill chuck with tapping chuck (Tool #3) and mount tool #4	~~1. [illegible]~~
2. Using .250 set-up block, set #4 tool height	1. Information sheet #2, page 5 in this learning guide
~~2. Using calculations from task [illegible] resource~~	2. Information sheet #13, page 19 in this learning guide.
~~#4, set [illegible] height~~	~~2. [illegible]~~
3. Set Z coordinate zero point	3. Information sheet #10, page 15 in this learning guide
4. Tap holes C and D.	~~4. [illegible]~~
5. Using resource #4, Turn off machine (End of program)	4. Information sheet #7, page 11 in this learning guide.
	5. Same as above.
6. Remove machined project from fixture and submit to instructor for evaluation.	6. pages 22+23 in this learning guide.

PERFORMANCE/PRODUCT CHECKLIST

Program:

Task No: 033

Student's Name: _____ Date Of Attempt: _____

Evaluator's Name: _____ Evaluation Site: _____

Performance Attempt: 1 2 3 4

Terminal Performance Objective: Tape and Punch N.C. program. Perform programmed machining operation.

Directions To The Student:

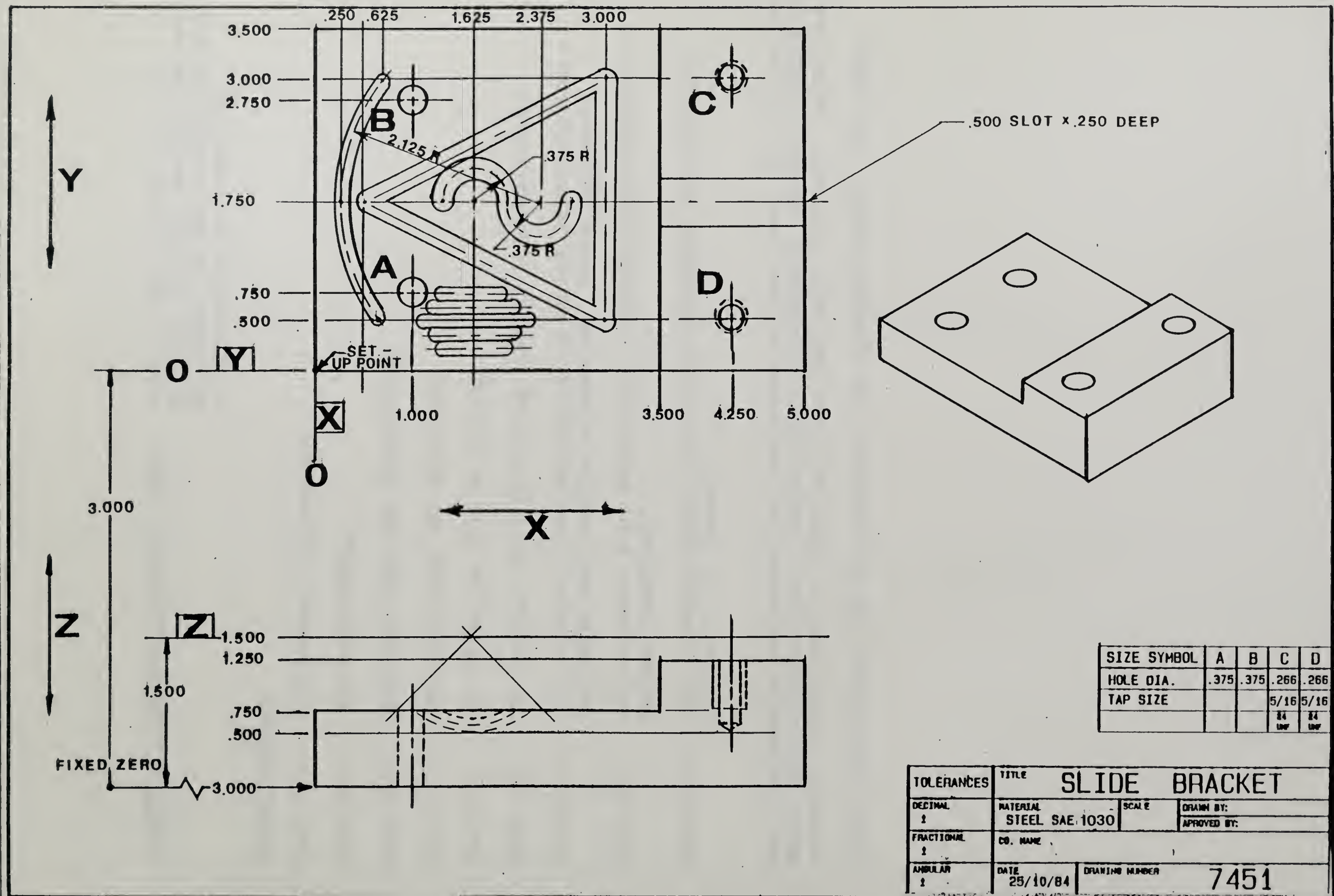
Before attempting this task for mastery, carefully review this checklist. You will be evaluated on the basis of this checklist. When you feel you are ready for evaluation, contact your instructor. You must complete your performance within 240 minutes and must score at least 80 out of 100 points or 80 % for mastery. Critical items are marked with an asterisk (*). These items must be satisfactorily completed.

Directions To The Evaluator:

The student will contact you when ready for the evaluation. The student must complete the performance within _____ minutes and must score _____ out of _____ points or _____ % and all items marked with an asterisk (*) must be satisfactorily completed.

CRITICAL ITEMS	ITLMS TO BE OBSERVED OR CHECKED	RATING YES	RATING NO
1.	Location and size of A and B holes. Location - 20 points Size - 10 points Clean up - 10 points		
2.	Location, size and depth of C and D holes Location - 20 points Size - 10 points Depth - 10 points		
3.	Finish and depth of tapped C and D holes Finish - 10 points Depth - 10 points		
	TOTAL POINTS EARNED =		

POINTS NEEDED FOR MASTERY = 80
TOTAL POINTS POSSIBLE = 100



SIZE SYMBOL	A	B	C	D
HOLE DIA.	.375	.375	.266	.266
TAP SIZE			5/16 24 UNF	5/16 24 UNF

TOLERANCES	TITLE SLIDE BRACKET		
DECIMAL ±	MATERIAL STEEL SAE 1030	SCALE	DRAWN BY: / APPROVED BY:
FRACTIONAL ±	CO. NAME		
ANGULAR ±	DATE 25/10/84	DRAWING NUMBER 7451	

COMPUTER NUMERICAL CONTROL TASKS - General CNC Information and Vertical Milling Machine Operations. All tasks on same workpiece and no triangulation required.

Tasks Outline

Task 030 - CNC General Information

Task 031 - CNC Programming

Task 032 - CNC Drill and Tap Programming

Task 033 - CNC Drill and Tap Machining

Task 034 - CNC Straight Slot Machining

Task 035 - CNC Angular Slot Machining (Linear interpolation)

Task 036 - CNC Circular Slot Machining (Circular interpolation - clockwise and counter clockwise - whole quadrant)

Task 037 - CNC Circular Slot Machining (Circular interpolation - partial quadrant)

Task 038 - CNC Circular Groove Machining (Circular interpolation in the X - Z planes)

All programming and machining performed on the Terco CNC Milltrainer - model 4440, control unit - model 4000, programming station - model 4426, automatic tape punch - model 4437 and the tape recorder-- model 4423.

Tasks 033 through 038 are shown on the attached print - No. 7451.

Solution

LAKE COUNTY AREA VOCATIONAL CENTER

NUMERICAL CONTROL PROGRAMMING FORM

TOOLING

Tool No.	Description	Speed(rpm)	Feed(ipm)
1.			
2.			
3.			
4.			
5.			

Part No.
Op. No.
Machine:
Fixture No.
Page_______of Page_______
Part
Material:
Dimensions:
Date:
By:

Operation	Seq. No.	Prep. Func.	X Position	Y Position	Z Position	I Position	J Position	K Position	Misc. Func.	Speed rpm	Feed ipm	Tool No.	Remarks

LAKE COUNTY AREA VOCATIONAL CENTER

COMPETENCY BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

Draft Copy

STUDENT LEARNING GUIDE

Produced By W. Pooler Date 1/15/85

TASK: Develop an N.C. Program for a Straight Slot using a Vertical Milling Machine and Perform the Machining Operation for this N.C. Program.

PURPOSE: This guide will help the student to apply the skills learned in task 032 to a basic vertical milling operation. This task will also reinforce the previously learned N.C. vertical milling machine operation/control skills

Program	Task	Est. Time	Prereq.
48.0503	034	4 hrs	032

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME _____ SOCIAL SECURITY NUMBER _____

LENGTH OF CONTRACT (NORMAL TIME IN HOURS) _____

2. TERMINAL PERFORMANCE OBJECTIVE

Given: The necessary information and performance exam.
You Will: Develop an NC Program for milling a straight slot.
How Well: To master this task you must score 80 out of 100 and score 80% on the performance exam.

2a. INTERMEDIATE OBJECTIVE(s)

1. Develop N.C. process steps
2. Develop an N.C. program for this operation.
3. Dry run program.
4. Perform the programmed operation.

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____. I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

Student's Signature _____

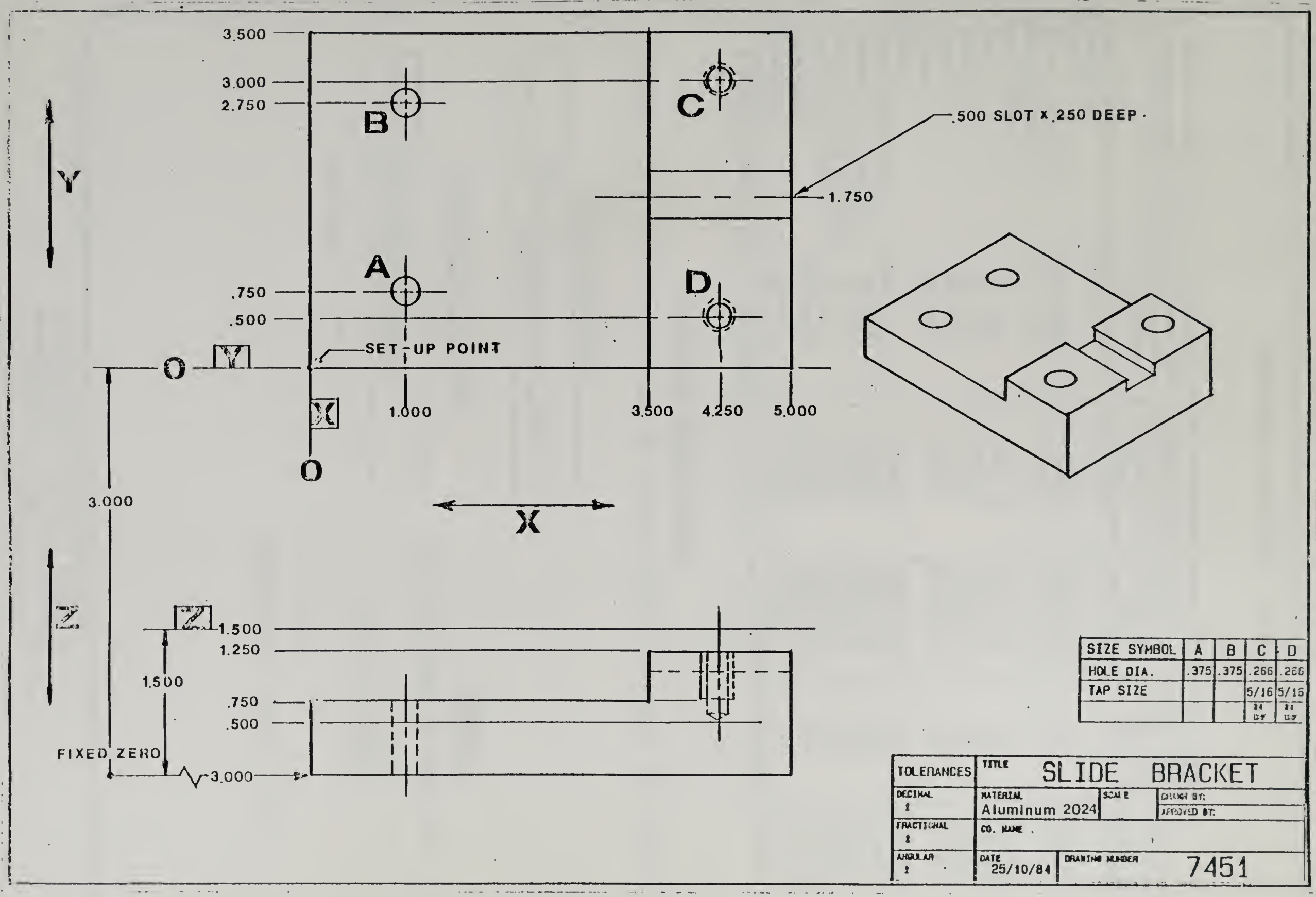
Instructor's Signature (verifies competency) _____

Program	Task	Page
48.050	034	8

INTERMEDIATE OBJECTIVE

1. Develop N.C. Process Steps

LEARNING STEPS (Activities)	RESOURCES
1. Analyze the part print.	1. Review information sheet #1, page 4 in this learning guide.
2. Determine the tooling needed for this project (3/8" end mill)	2. Review information sheet #1, page 4 in this learning guide.
3. Determine machining feeds and speeds. List values on N.C. program sheet Use low value on the Tables	3. Review information sheet #2, #3, #4 pages 5, 6 and 7 in this learning guide.
4. Determine process steps and list in operation column of N.C. program sheet	4. Information sheet #4 page 7 in this learning guide
5. Go to next intermediate objective	5. Intermediate objective #2, page 8 in this learning guide.



SIZE SYMBOL	A	B	C	D
HOLE DIA.	.375	.375	.266	.266
TAP SIZE			5/16	5/16
			24 DP	24 DP

TOLERANCES	TITLE SLIDE BRACKET		
DECIMAL ±	MATERIAL Aluminum 2024	SCALE	DRAWN BY: / APPROVED BY:
FRACTIONAL ±	CO. NAME		
ANGULAR ±	DATE 25/10/84	DRAWING NUMBER 7451	

Information Sheet #2 page 4

INFORMATION SHEET # 2

Suggested Cutting Rates Using High Speed Steel Cutting Tools					
Material	Drilling sfm	Reaming sfm	Turning sfm	Tapping sfm *	Milling sfm
Aluminum	250-600	100-300	400-1000	90	300-800
Brass					
free cutting	150-300	130-200	225-350	100	150-300
Bronze, soft	100-250	75-180	150-225	75	100-250
Cast iron					
Soft	75-150	60-100	100-150	40	75-150
Medium	70-100	30-65	75-120	30	70-100
Hard	60-100	20-55	50-90	20	50-80
Copper	60-100	40-60	100-200	40	80-140
Steel					
Free machining	100-145	60-100	125-200	40	100-180
Under 0.3 carbon	70-120	50-90	75-175	35	70-120
0.3 to 0.6 carbon	55-90	45-70	65-120	25	55-90
Over 0.6 carbon	40-60	40-50	60-80	20	40-60
Magnesium	300-650	150-350	600-1200	150	300-600
Titanium	30-60	10-20	25-55	30	25-50

* Suggested rates - machining variables may require changing rates

END MILL SPEED RATES

Cutting rate can be converted to spindle speed by using the formula:

(Basic formula)

$$\text{rpm} = \frac{\text{sfm} \times 12}{\pi \times \text{diameter of cutter}}$$

(Simplified formula)

$$\text{rpm} = \frac{C \times \text{sfm}}{\text{diameter of cutter}}$$

Constant "C" = 4

Example

5/16 end mill in SAE 1030 steel

$$\text{rpm} = \frac{4 \times 70}{.3125}$$

rpm = 896

Rounded off speed = 900

INFORMATION SHEET # 3

END MILL FEED RATES

Suggested Cutting Rates Using High Speed Steel Tools		
	¼ - ½ inch diameter end mill	1/2 - 1 inch diameter end mill
Material	IPT	IPT
Aluminum	.003 to .006	.006 to .009
Brass, free cutting	.003 to .005	.005 to .008
Bronze, soft	.002 to .004	.002 to .007
Cast iron		
Soft	.003 to .005	.005 to .008
Medium	.0025 to .005	.005 to .007
Hard	.002 to .0035	.0035 to .005
Copper	.002 to .004	.004 to .006
Magnesium	.003 to .006	.006 to .010
Steel		
Free machining	.002 to .004	.004 to .006
Under 0.3 carbon	.001 to .0025	.0025 to .004
0.3 to 0.6 carbon	.0005 to .002	.002 to .003
over 0.6 carbon	.0003 to .001	.001 to .002
Titanium	.001 to .0025	.0025 to .004

End mill cutting feed rate can be found by using the formula:

IPM = IPT x number of teeth x RPM

IPM = inches per minute
IPT = inches per tooth
RPM = rotation per minute

Example

5/16 - 4 tooth end mill in SAE 1030 steel. (RPM = 896)

IPM = .001 x 4 x 896

IPM = 3.58

Rounded off feed = 3.50 inches

AKE COUNTY AREA VOCATIONAL CENTER

UMERICAL CONTROL

PROGRAMMING FORM

TOOLING			
Tool No.	Description	Speed(rpm)	Feed(ipm)
1.			
2.			
3.			
4.			
5.			

t No.		Machine:	Fixture No.	Page_____of Page_____
rt		Material:	Dimensions:	Date: By:

peration	Seq. No.	Prep. Func.	X Position	Y Position	Z Position	I Position	J Position	K Position	Misc. Func.	Speed rpm	Feed ipm	Tool No.	Remarks

INTERMEDIATE OBJECTIVE

2. Develop an N.C. Program For This Operation

LEARNING STEPS (Activities)	RESOURCES
1. Complete the heading portion of N.C. program form.	1. Standard N.C. program form (Same as information sheet #4, page 7 in this learning guide)
2. List block data for the entire program.	2. Standard N.C. program form, page 7 in This learning guide
3. Proof read and submit N.C. program to instructor	3. Instructors N.C. program solution sheet, page 12 in this learning guide
4. Go to next intermediate objective	4. Intermediate objective #3, page 9 in This learning guide

Program	Task	Page
[illegible]	[illegible]	[illegible]

INTERMEDIATE OBJECTIVE

3. Dry Run Program

LEARNING STEPS (Activities)	RESOURCES
1. Review mill machine controls	1. Video tape on Terco programmer controls
2. Enter program data	2. Terco control unit CNC 4000 and pages 6 through 11 in Terco manual
3. Dry run program	3. Terco programming station CNC 4426
4. Go to next intermediate objective	4. Intermediate objective # 4, page 10 in this learning guide.

Program	Task	Page
18.000	4	9

INTERMEDIATE OBJECTIVE

4. Perform The Programmed Operation

LEARNING STEPS (Activities)	RESOURCES
1. Mount part on Terco Table and set tool to Z, Y Z zero start position.	1. Terco manual page 12, #7451 part from Task 033 and 3/8" end mill.
2. Mill slot.	2. Information sheet #1, page 4 in This learning guide.
3. Remove part from fixture and submit for grading.	3. Submit to instructor for grading. Performance product/checklist, page 11, and score sheet, page 13 in This learning guide

PERFORMANCE/PRODUCT CHECKLIST

Program: Machine Shop

Task No: 037 A

Student's Name: _____ Date Of Attempt: _____

Evaluator's Name: _____ Evaluation Site: _____

Performance Attempt: 1 2 3 4

Terminal Performance Objective: Write an N.C. Program and mill a straight slot

Directions To The Student:

Before attempting this task for mastery, carefully review this checklist. You will be evaluated on the basis of this checklist. When you feel you are ready for evaluation, contact your instructor. You must complete your performance within 30 minutes and must score at least 80 out of 100 points or 80 % for mastery. Critical items are marked with an asterisk (*). These items must be satisfactorily completed.

* 4 point per answer

Directions To The Evaluator:

The student will contact you when ready for the evaluation. The student must complete the performance within _____ minutes and must score _____ out of _____ points or _____ % and all items marked with an asterisk (*) must be satisfactorily completed.

CRITICAL ITEMS	ITEMS TO BE OBSERVED OR CHECKED	RATING YES	RATING NO
	Speed - 900		
	Feed - 3.50		
N000	Start		
N001	Clamp part		
N002	Set tool		
N003	Rapid to 1st. Cut		
N004	Rapid to depth		
N005	Mill 1st. Cut		
N006	Retract tool		
N007	Rapid to 2nd. cut		
N008	Rapid to depth		
N009	Mill 2nd. cut		
N010	Retract tool		
N011	Rapid to zero		
N012	Stop		
N013	Unclamp part		
	slot width		
	slot depth		
	slot location		
	Surface finish		

TOTAL POINTS EARNED =

POINTS NEEDED FOR MASTERY =
TOTAL POINTS POSSIBLE =

Solution Sheet

LAKE COUNTY AREA VOCATIONAL CENTER

NUMERICAL CONTROL PROGRAMMING FORM

TOOLING

Tool No.	Description	Speed(rpm)	Feed(ipm)
1.	5/16" 3/8 SH End Mill	3500	10
2.			
3.			
4.			
5.			

Part No. 7451 | Machine: Vert. Mill | Fixture No. | Page 1 of Page 1

Part: Slide Bracket | Material: Aluminum | Dimensions: Tracing | Date: | By:

Operation	Seq. No.	Prep. Func.	X Position	Y Position	Z Position	I Position	J Position	K Position	Misc. Func.	Speed rpm	Feed ipm	Tool No.	Remarks
[illegible]	[illegible]	G00	02000	15[illegible]									
Mill to Depth	002				05000				03	59	5		End
Mill Left	003	G01	50000						03	59	10		
Select Other	004	G00			0000				05				
Rapid to Hole	005	G00	2000	1.2265									
Drill to Depth	006				05000				03	50	5		2 Dwell
Mill 2nd Cut	007	G01	5000						03	50	10		
Select Other	008	G00			00000				05				
Rapid Home	009	G00	0000	00000					07				
Stop	011								[illegible]				Program Stop

48.0503 034 13

APPENDIX III

Medical Assisting Learning Guides

Illinois State Board of Education

Department of Adult, Vocational and Technical Education
Research and Development Section

Product Abstract

1. Title of material 8 Medical Assisting Learning Guides - titles listed on reverse side

2. Date material was completed FY85

3. Please check one: New material X Revised material ____ Field-tested material ____

4. Originating agency Lake County Area Vocational Center

   Address 19525 West Washington Street, Grayslake IL Zip Code 60030

5. Name(s) of developer(s) Rose Meyer

   Address Lake County Area Vocational Center Zip Code ____

6. Developed pursuant to Contract Number R-99-25-X-0000-499

7. Subject Matter (Check only one according to Department of Education Code):

   Code

   ____ 01 Agricultural Education
   ____ 03 Business and Office Education
   ____ 04 Distributive Education
   ____ 07 Health Occupations Education
   ____ 09 Home Economics Education
   ____ 10 Industrial Arts Education
   ____ 16 Technical Education
   X 17 Trade and Industrial Education
   ____ 22 Cooperative Education
   ____ Career Education
   ____ Other (Specify) ____

8. Education Level:

   ____ Pre-K Thru 6
   X Post-Secondary
   ____ Administrator (Pre-Service)
   ____ 7-8
   X Adult
   ____ 9-10
   ____ Teacher (Pre-service)
   ____ Other (Specify) ____
   X 11-12

9. Intended for Use By:

   X Student
   ____ Teacher Educator
   ____ Other (Specify) ____
   X Classroom Teacher
   ____ Guidance Staff
   X Local Administrator
   ____ State Personnel

10. Student Type:

    X Regular
    ____ Limited-English Proficiency
    ____ Disadvantaged
    ____ Handicapped
    ____ Other (Specify) ____

11. Medium and Format of Materials:

    X HARDCOPY
    No. of pages various
    ____ Paper bound
    ____ Hard bound
    X Loose-leaf
    Photos: Yes ____ No ____
    Diagrams: Yes ____ No ____

    ____ VIDEOTAPE
    ____ Minutes
    ____ B & W
    ____ Color
    ____ inches

    ____ FILM
    ____ Minutes
    ____ B & W
    ____ Color
    ____ mm

    ____ MICROFICHE
    ____ B & W
    ____ Color

___ SLIDES

No of frames _____
___ B & W
___ Color
___ Audio
___ Carousel provided
___ Other packaging used
(Specify) _____

___ FILM STRIPS

No of frames _____
___ B & W
___ Color
___ Audio

___ AUDIO

___ Automatic synch
___ _____ Hz
___ Manual cue
___ Reel
___ Cassette
___ Cartridge

___ OTHER

Specify: _____

12. Availability:

_____ One copy free
X In ERIC system (No. _____)
For sale @ $ _____ per copy
_____ Not available
_____ Loan copy available

Contact: Name East Central Network for Curriculum Coord. Phone (217 786-6375
Address Illinois Vocational Curriculum Center
Sangamon State University, Building F
Springfield IL Zip Code 62708

13. Copyright Restrictions:

Contact: Name NONE Phone ( )
Address _____ Zip Code _____

14 What level(s) of assistance is required to provide implementation of this outcome?

_____ awareness X understanding
_____ deciding X implementing

15. Are Consultive/Inservice (or staff development) available? Yes _____ No _____

Contact: Illinois State Board of Education
Department of Adult, Vocational and Technical Education
Research and Development Section, E-426
100 North First Street
Springfield, IL 62777
(217) 782-4620

16 General Description (State the general objective and suggested method of use. Summarize the content and tell how it is organized. Write the description so that it can be used to promote the material. Continue on back of this sheet or on another sheet, if necessary)

Competency-based learning guides for learning basic skills/knowledge

17 Person Completing this Abstract: Richard W. Glogovsky

Full Address Lake County Area Vocational Center
19525 West Washington Street
Grayslake IL 60030

LEARNING GUIDE TITLES

1. Demonstrate use of balances
2. Perform pipetting
3. Measure and calculate dosage
4. Operate centrifuge
5. Perform reticulocyte count
6. Perform bleeding and capillary coagulation times
7. Prepare solutions
8. Perform mononucleosis test

LAKE
COUNTY
AREA
VOCATIONAL
CENTER

COMPETENCY-BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

STUDENT LEARNING GUIDE

Produced By Rosemarie Meyer, RN, BSN Date 4/85

TASK: * PERFORM MONONUCLEOSIS TEST (HIGH TECH)

PURPOSE: INFECTIOUS MONONUCLEOSIS IS AN IMPORTANT ACUTE INFECTIOUS DISEASE, PROBABLY VIRAL IN ORIGIN. THREE DISTINCT GROUPS OF ANTIBODIES ARE FOUND IN MONONUCLEOSIS: HETEROPHIC, EPSTEIN-BARR VIRUS (EBV), AND MULTIPLE AUTOANTIBODIES, ISOANTIBODIES, AND HETEROANTIBODIES. HETEROPHIL ANTIBODIES ARE MUCH MORE EASILY DETECTED, AND FOR THIS REASON ROUTINE TESTS FOR THE PRESENCE OF HETEROPHIC ANTIBODIES ARE USED FOR THE DIAGNOSIS OF INFECTIOUS MONONUCLEOSIS, ALONG WITH HEMATOLOGIC FINDINGS. THIS LEARNING GUIDE WILL ASSIST THE STUDENT TO PERFORM A MONONUCLEOSIS TEST.

MEDICAL ASSISTING

emf

Program	Task	Est.Time	Prereq.
07.0904	565	4	

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME _____ SOCIAL SECURITY NUMBER _____

LENGTH OF CONTRACT (NORMAL TIME IN HOURS) 4 H

2. TERMINAL PERFORMANCE OBJECTIVE

Given the necessary tools and equipment, perform a mononucleosis test. To master this task you must score 9 out of 10 (90%) on a written evaluation test and 10 out of 11 (90%) on a performance checklist.

2a. INTERMEDIATE OBJECTIVE(s)

1. Describe mononucleosis.
2. Perform mononucleosis test.

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____. I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

Student's Signature _____

Instructor's Signature (verifies competency) _____

INTERMEDIATE OBJECTIVE #1

DESCRIBE MONONUCLEOSIS.

LEARNING STEPS (Activities)	RESOURCES
1. Read Resource #1 for information on mononucleosis.	1. Information Sheet 565-001-001, "Infectious Mononucleosis," pg. 4 , in this SLG. (Information taken from Basic Techniques for the Medical Laboratory by J. Jorgenson and K. Ringsrud, 2nd edition.
2. Complete Resource #2 for a review on mononucleosis.	2. Job Sheet 565-001-002, "Review Mononucleosis," pg. 7 , in this SLG. See activity key book or instructor for evaluation.
3. Proceed to Resource #3.	3. I.O. #2, pg. 10, in this SLG.

INFORMATION SHEET

565 - 001 - 001

"INFECTIOUS MONONUCLEOSIS"

Infectious mononucleosis is an important acute infectous disease, probably viral in origin, that is represented by a relatively well-defined hematologic picture. Three distinct groups of antibodies are found in infectious mononucleosis: heterophil antibodies, Epstein-Barr virus (EBV) antibodies, and multiple autoantibodies, isoantibodies, and heteroantibodies. Heterophil antibodies are antibodies that react with an antigen entirely different from the phylogenetically unrelated to the antigen responsible for their production. They are agglutinins that react particularly to sheep and horse red cells and are mainly class G immunoglobulins (IgG). Heterophil antibodies are detected by the Paul-Bunnell test.

Infectious mononucleosis is now thought to be caused by the EBV, a member of the herpes group of viruses. Antibodies to this virus are produced early in the disease and can be detected by complement fixation tests and immunofluorescence techniques. Demonstration of EBV antibodies is a complicated process and is beyond the scope of most routine laboratories. Heterophil antibodies are much more easily detected, and for this reason routine tests for the presence of heterophil antibodies are used for the diagnosis of infectious mononucleosis, along with hematologic findings.

Heterophil antibodies are present in low titer in the serum of normal persons and are known as Forssman antibodies. They resemble the antibodies found in infectious mononucleosis in that they agglutinate sheep red cells, but differ from them in that they are absorbed by an emulsion of guinea pig kidney, which is rich in Forssman antigen, and are not absorbed by beef cells, which are poor in Forssman antigen. In cases of serum sickness, or sensitization to animal (usually horse) serum, a further type of sheep red cell agglutination antibody is found and may be present in high titer. However, this is again distinguished from the antibody of infectious mononucleosis by being absorbed by guinea pig kidney and from Forssman antibodies by being absorbed by beef red cells. This is summarized in Table 8-1. This comparison was devised by Davidsohn in 1935 to 1937 and is used today as the basis for presumptive and differential tests.

TABLE 8-1. Comparison of Forssman, serum sickness, and infectious mononucleosis antibodies

	ABSORBED BY	
Antibody	Guinea pig Kidney	Beef red blood cells
Forssman	Yes	No
Serum sickness	Yes	Yes
Infectious mononucleosis	No	Yes

The sheep cell agglutinins of infectious mononucleosis can be distinguished from those of serum sickness and other conditions by means of a differential test, using absorption with guinea pig kidney and beef red cell antigens. The antibody that can be removed by absorption with guinea pig kidney is known as the Forssman antibody, and the guinea pig kidney as the Forssman antigen. The classical sheep red cell agglutination test is carried out in two steps: the presumptive test of Paul and Bunnell, and the differential test of Paul, Bunnell, and Davidsohn. These are the reference tests from which the rapid testing procedures have evolved. Modifications of these classical procedures utilize horse red cells instead of sheep red cells.

Under normal circumstances, rapid screening tests for infectious mononucleosis are done for the presence of heterophil antibodies. Horse red cells are usually used rather than sheep red cells, as they are more sensitive to heterophil antibodies. Persons suffering from infectious mononucleosis begin developing heterophil antibodies shortly after the appearance of the symptoms, usually during the first 2 weeks. Highest titers are found during the second and third weeks of the illness. The titer bears no relationship, however, to the severity of the illness. As a rule, heterophil sheep cell agglutinins appear in only 50-80 percent of cases of infectious mononucleosis, so negative results can be obtained when the disease is present. Negative tests therefore do not rule out the possibility of the disease.

The test for heterophil antibodies is of confirmatory diagnostic importance in cases of infectious mononucleosis with typical clinical and hematologic findings. It is of a deciding diagnostic importance early in the disease when there are unusual clinical findings and hematologic signs, some of which may be caused by complicating factors.

Recently, faster and easier screening tests have been introduced commercially and have replaced the laborious presumptive and differential tests in many laboratories. One such test is the spot test of Lee et al. These rapid slide screening tests are based on the following principles: (1) the use of horse red cells instead of sheep red cells makes the test more sensitive and thus is especially valuable for low-titer serum found in the early stages of the disease; (2) the unwashed preserved horse red cells remain in a usable condition for at least 3 months and give stronger and quicker agglutination with infectious mononucleosis serum than do horse red cells preserved with Formalin; (3) some noninfectious mononucleosis serum also has a high horse agglutinin titer, and therefore serological tests cannot depend on titers alone; and (4) fine suspensions of guinea pig kidney and of beef red cell stromata give satisfactory instant absorption of antibodies and a clear-cut differentiation between infectious and noninfectious mononucleosis serum.

These tests are done on a slide. The serum from the patient is mixed thoroughly with guinea pig kidney on one spot of the slide and with beef red cell stromata on another spot. The unwashed horse red cells (preserved) are added immediately to both spots. These reagents are available commercially in the form of test kits. Directions must be followed carefully. Agglutination is observed on both spots of the slide 1 minute after the final mixing. If agglutination

is stronger on the spot where the guinea pig kidney suspension was mixed with the patient's serum, the test is positive. If it is stronger on the spot where the beef red cells were mixed with the patient's serum, the test is considered negative. If the agglutination is equal on both spots, the test is negative. If no agglutination appears on either spot, the test is negative. One commercially available test kit utilizing this principle is called Mono-Spot and is manufactured by Ortho Diagnostics, Raritan, NJ.

The glass slides used for these rapid screening tests must be carefully cleaned under running water. Use of detergent could cause errors in the results. Most of the widely used immunologic assays for infectious mononucleosis are highly sensitive. It is still necessary, however, to use adequate and proper control programs as the only dependable method of detecting sources of technical errors. When the results are not clearcut, it is always important to repeat them and to conduct additional dependable serological tests. Several tests are available. Repeating tests at a later date is also helpful.

JOB SHEET

565-001-002

"REVIEW MONONUCLEOSIS"

SELECT THE BEST ANSWER.

1. Infectious mononucleosis is an important acute infectious disease, probably _____ in origin, and well-represented by a well-defined hematologic picture.

   A. infectious
   B. serous
   C. viral
   D. fungal

2. Infectious mononucleosis is now thought to be caused by _____, a member of the herpes group of viruses.

   A. heterophil
   B. IgG
   C. Forssman
   D. EBU

3. Heterophil antibodies are present in low titer in the serum of normal persons and are known as _____.

   A. Epstein-Baan antibodies
   B. Autoantibodies
   C. Isoantibodies
   D. Forssman antibodies

4. In cases of serum sickness, or sensitization of animal (usually horse) serum, a type of sheep red cell agglutination antibody is found and may be present in _____ titer.

   A. high
   B. low
   C. neutral
   D. iso

5. The cell agglutinins of infectious mononucleosis can be distinquished from those of serum sickness and other conditions by means of a differential test.

   A. horse
   B. rabbit
   C. sheep
   D. beef

6. The antibody removed by absorption with guinea pig kidney is known as the Forssman _____.

   A. antigen
   B. antibody
   C. agglutinin
   D. titer

7. Rapid screening tests for infectious mononucleosis are done for the presence of _____ antibodies.

   A. EBU
   B. heterophil
   C. heteroantibodies
   D. isoantibodies

8. Patients suffering from infectious mononucleosis begin developing heterophil antibodies shortly after the appearance of symptoms, usually during the first _____ weeks.

   A. two
   B. three
   C. four
   D. five

9. _____ titers are found during the second and third weeks of illness.

   A. Lowest
   B. Normal
   C. Highest

10. The test for heterophil antibodies is of confirmatory diagnostic importance in cases of infectious mononucleosis with typical clinical and _____ findings.

   A. screening
   B. differential
   C. comparing
   D. hematologic

11. One faster and easier commercial screening test is the _____ test.

   A. mono
   B. serum
   C. IgG
   D. spot

12. The rapid slide test is _____ when agglutination appears on both spots.

    A. positive
    B. negative

13. The commercial agglutination test kit used in the M.A. lab is _____.

    A. Lee et al
    B. mono
    C. UCG
    D. EBU

14. Glass slides used for rapid screening tests must be cleaned under running water. Use of _____ could cause errors in the results.

    A. disinfectants
    B. detergents
    C. antiseptics
    D. solutions

15. It is necessary to use adequate and proper _____ programs as the only dependable method of detecting sources of technical errors.

    A. sample
    B. specimen
    C. control
    D. labeling

INTERMEDIATE OBJECTIVE #2

PERFORM MONONUCLEOSIS TEST.

LEARNING STEPS (Activities)	RESOURCES
1. Observe Resource #1 for a demonstration on performing a mononucleosis test.	1. See instructor.
2. Practice performing a mononucleosis test by completing Resource #2.	2. Job Sheet 565-002-002, "Practice Performing a Mononucleosis Test," Pg. 11, in this SLG.
3. When you feel you have mastered this task, complete Resource #3.	3. Performance Checklist, pg.13 , in this SLG. See instructor for evaluation.
4. Complete Resource #4 for a written evaluation.	4. Written Criterion Examination, "Perform Mononucleosis Test," in LRC. See LRC secretary.
5. Proceed to Resource #5 for the next learning guide.	5. See instructor.

JOB SHEET

565-002-002

"PRACTICE PERFORMING A MONONUCLEOSIS TEST"

DIRECTIONS TO THE STUDENT:

Given the necessary tools and equipment, practice performing a mononucleosis test.

NECESSARY TOOLS AND EQUIPMENT:

Mono spot kit
Wholeblood (Capillary or Venous)

PROCEDURE:

TESTING OF SPECIMENS

1. Fill capillary with patient's specimen up to mark and empty into center of middle section of the slide.

2. Place one drop of Negative Control Serum in right section and one drop of Positive Control Serum in left section of the slide.

3. Add one drop of MONO-TEST Reagent to each section of the slide.

4. Mix separately, and spread each mixture uniformly over an area approximately 1 inch in diameter. Use a clean disposable stirrer for each mixture.

USING GLASS SLIDE

5. Rock slide gently for 2 minutes and observe immediately for agglutination by using a high intensity lamp for lateral illumination of the slide and observing against a dark background.

USING DISPOSABLE CARD SLIDE

5. Rock card gently for 1 minute, then leave it undisturbed for another 1 minute, and observe immediately for agglutination.

TITRATION PROCEDURE

Although the heterophile antibody titer has been said to bear no relation to the severity or cause of the disease, some laboratories are requested to establish an antibody titer, particularly as a sequential determination for an individual patient.

The specimen is titered by preparing 2-fold serial dilutions from 1:2 to 1:32 in isotonic saline (0.85% sodium chloride) and testing each dilution with MONO-TEST Reagent.

1. Place 5 test tubes into a test tube rack and label them #1 - #5.

2. Dispense 0.5 ml of isotonic saline into each tube.

3. Add 0.5 ml of specimen to tube #1, mix thoroughly.

4. Transfer 0.5 ml from tube #1 to tube #2, mix thoroughly.

5. Continue transferring 0.5 ml aliquots from tube #2 through tube #5, mixing thoroughly before each transfer. It is not necessary to discard 0.5 ml from tube #5 (the 1:32 dilution); this may be retained should further dilutions be required.

6. Test the undiluted specimen along with each dilution as described under Testing of Specimens."

RESULTS

Specimens which contain serologically detectable I.M. antibodies will agglutinate the MONO-TEST Reagent. Agglutination (clumping) of the MONO-TEST Reagent is interpreted as a positive result. No agglutination of a finely granular pattern should be reported as a negative result.

The following pictures illustrate positive and negative results:

POSITIVE

NEGATIVE

The I.M. titer of a specimen is interpreted as the reciprocal of the last dilution to produce a positive result(end point).

PERFORMANCE/PRODUCT CHECKLIST

Program: MEDICAL ASSISTING

Task No: 565

Student's Name: _____ Date Of Attempt: _____

Evaluator's Name: _____ Evaluation Site: _____

Performance Attempt: 1 2 3 4

Terminal Performance Objective:

Given the necessary tools and equipment, perform mononucleosis test.

Directions To The Student:

Before attempting this task for mastery, carefully review this checklist. You will be evaluated on the basis of this checklist. When you feel you are ready for evaluation, contact your instructor. You must complete your performance within 10 minutes and must score at least 10 out of 11 points or 90 % for mastery. Critical items are marked with an asterisk (*). These items must be satisfactorily completed.

Directions To The Evaluator:

The student will contact you when ready for the evaluation. The student must complete the performance within 10 minutes and must score 10 out of 11 points or 90 % and all items marked with an asterisk (*) must be satisfactorily completed.

CRITICAL ITEMS	ITLMS TO BE OBSERVED OR CHECKED	RATING YES	RATING NO
*	1. Wash hands.		
*	2. Fill capillary up to mark.		
*	3. Empty into center of middle section of the slide.		
*	4. Place one drop of Negative Control Serum on right side of slide.		
*	5. Place one drop of Positive Control Serum on left side of slide.		
*	6. Add one drop of Mono Test Reagent to each section of the slide.		
*	7. Mix separately.		
*	8. Spread uniformly.		
	9. Rock glass slide gently for 2 minutes or on disposable card for 1 minute.		
*	10. Read and record results.		
*	11. Clean up working area.		

TOTAL POINTS EARNED =

POINTS NEEDED FOR MASTERY = 10
TOTAL POINTS POSSIBLE = 11

MEDICAL ASSISTING

PROGRAM 07.0904

CRITERION EXAM

TASK = 565

DIRECTIONS:

THE PURPOSE OF THIS EXAM IS TO DETERMINE WHETHER OR NOT YOU HAVE UNDERSTOOD THE INFORMATION ON PERFORM MONONUCLEOSIS TEST.

Each of the questions or incomplete statements below is followed by several words, phrases, or a series of numbers. Choose the one which best answers the question or completes the statement correctly. Place the letter associated with that choice (A,B,C or D) in the numbered blank space on your ANSWER SHEET. DO NOT WRITE ON THIS TEST!!! To master this exam you must answer 9 out of 10 items correctly, 90 %.

EVALUATION SHEET

WRITTEN CRITERION EVALUATION

"PERFORM MONONUCLEOSIS TEST"

SELECT THE BEST ANSWER.

1. Infectious mononucleosis is an important acute infectious disease, probably _____ in origin, and well-represented by a well-defined hematologic picture.

   A. infectious
   B. serous
   C. viral
   D. fungal

2. The cell agglutinins of infectious mononucleosis can be distinquished from those of serum sickness and other conditions by means of a differential test.

   A. horse
   B. rabbit
   C. sheep
   D. beef

3. _____ titers are found during the second and third weeks of illness.

   A. Lowest
   B. Normal
   C. Highest

4. The commercial agglutination test kit used in the M.A. lab is _____.

   A. Lee et al
   B. mono
   C. UCG
   D. EBU

5. It is necessary to use adequate and proper _____ programs as the only dependable method of detecting sources of technical errors.

   A. sample
   B. specimen
   C. control
   D. labeling

6. Reasons suffering from infectious mononucleosis begin developing heterophil antibodies shortly after the appearance of symptoms, usually during the first _____ weeks.

   A. two
   B. three
   C. four
   D. five

7. The rapid slide test is _____ when agglutination appears on both spots.

   A. positive
   B. negative

8. The antibody removed by absorption with guinea pig kidney is known as the Forssman _____.

   A. antigen
   B. antibody
   C. agglutinin
   D. titer

9. One faster and easier commercial screening test is the _____test.

   A. mono
   B. serum
   C. IgG
   D. spot

10. Rapid screening tests for infectious mononucleosis are done for the presence of _____ antibodies.

   A. EBU
   B. heterophil
   C. heteroantibodies
   D. isoantibodies

LAKE COUNTY AREA VOCATIONAL CENTER

COMPETENCY-BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

STUDENT LEARNING GUIDE

Produced By Rosemarie Meyer Date 11/84

TASK: DEMONSTRATE USE OF BALANCES

PURPOSE: Many and varied pieces of laboratory apparatus are used in performing clinical determinations, and the knowledge of the proper use and handling of this equipment is an important part of any course of study dealing with laboratory work. Probably some of the most important instruments are the various types of balances used to measure weight or mass (gravimetric analysis) in preparing the reagents and standard solutions used in the laboratory. This learning guide will assist you to demonstrate the use of balances.

MEDICAL ASSISTING

emf

Program	Task	Est.Time	Prereq.
07.0904	002E	6 hrs.	

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME _____ SOCIAL SECURITY NUMBER _____

LENGTH OF CONTRACT (NORMAL TIME IN HOURS): 6 Hours

2. TERMINAL PERFORMANCE OBJECTIVE

Given the necessary tools and equipment, demonstrate the use of balances. To master this task you must score 24 out of 24 (100%) on a performance evaluation and 14 out of 15 (90%) on a written evaluation.

2a. INTERMEDIATE OBJECTIVE(s)

1. Describe types of balances.
2. Demonstrate use of balances.

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____. I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

Student's Signature _____

Instructor's Signature (verifies competency) _____

Program	Task	Page
07.0904	002F	1

INTERMEDIATE OBJECTIVE #1

DESCRIBE TYPES OF BALANCES.

LEARNING STEPS (Activities)

1. Read Resource #1 for information on types of balances and the use of balances.

2. View Resource #2 for a visual presentation on the types of balances and their uses.

3. Complete Resource #3 for a review on types of balances and their use.

4. Proceed to Resource #4.

RESOURCES

1. Information Sheet 002E-001-001, "Types of Balances," Page 3 in this SLG.

   Information taken from textbook: "Basic Techniques for the Medical Laboratory" by Linne and Ringsrud, 2nd edition, McGraw Hill Book Co.

2. Biotech 8107, in the LRC.

   See LRC Secretary.

3. Job Sheet 002E-001-001 "Review Types of Balances and Their Uses," pages 12 - 14 in this SLG.

4. IO #2, page 15 in this SLG.

WEIGHING AND THE USE OF BALANCES

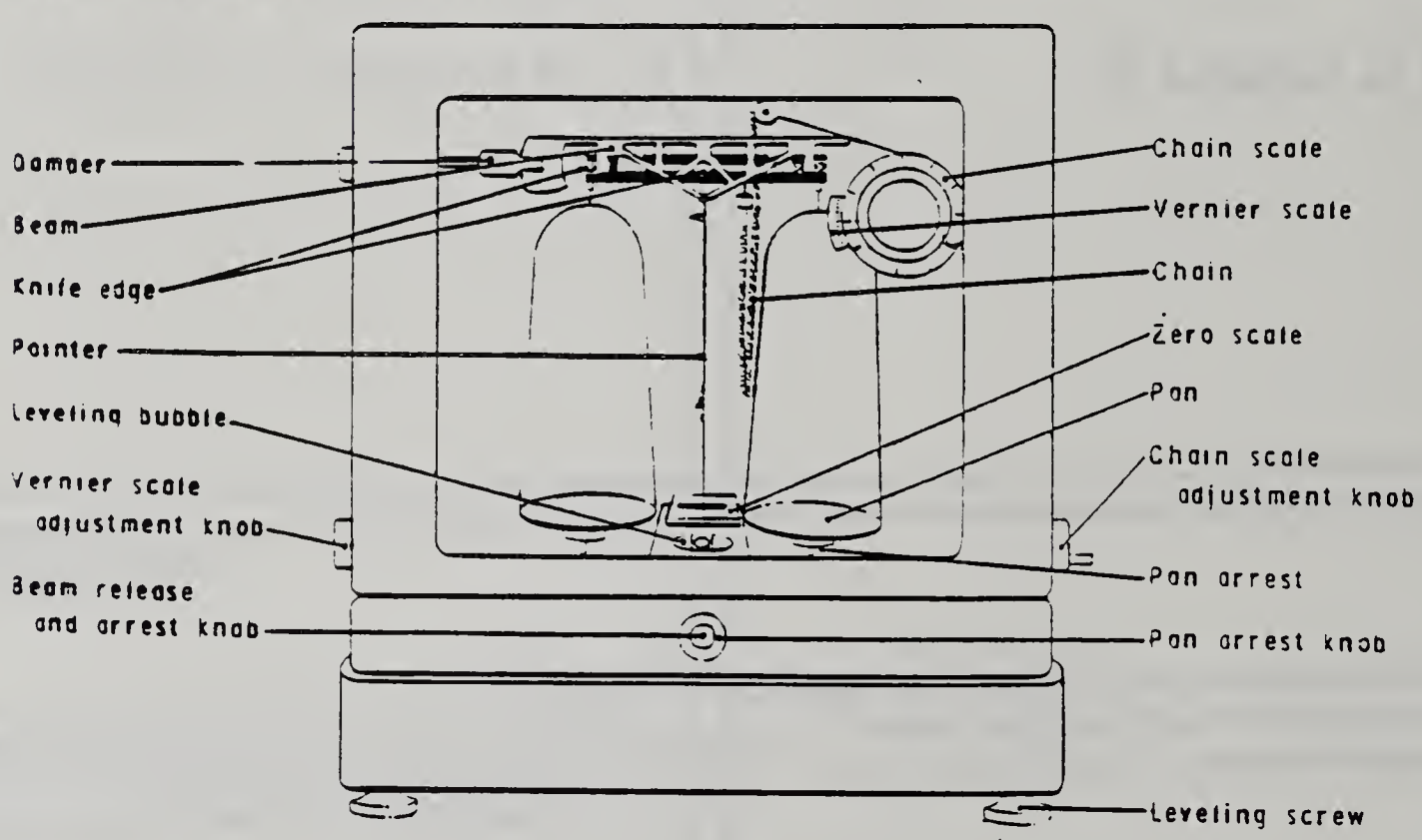
Many and varied pieces of laboratory apparatus are used in performing clinical determinations, and the knowledge of the proper use and handling of this equipment is an important part of any course of study dealing with laboratory work. Probably some of the most important instruments are the various types of balances used to measure weight or mass (gravimetric analysis) in preparing the reagents and standard solutions used in the laboratory. This is a method of quantitative analysis in the laboratory. Almost every procedure performed in the laboratory depends to some extent on the use of a balance. The balance considered to be the "backbone" of the clinical chemistry laboratory is the analytical balance. This balance and other types—namely the triple-beam, Cent-O-Gram, and torsion balances—will be discussed in this section. A single laboratory is likely to have all of these types, and for this reason a student in a laboratory course should understand how the various balances work. Every laboratory should have some type of analytical balance and at least one other less sensitive type of balance. These are the minimum requirements for weighing instruments.

Balances are used to weigh the chemicals used to prepare the many chemical solutions needed in the laboratory. Some solutions require more accurately weighed chemicals than others. The accuracy needed depends on what the solution is to be used for. One must decide what type of balance (or scale) is most appropriate for the precision or reproducibility required in weighing the chemicals to be used for a particular solution. The different kinds of balances are suited to particular needs. A balance that sacrifices precision for speed should not be used when precision is needed.

Analytical balance

Many different types of analytical balances are made by different companies and they have

Fig. 1-8. Manual analytical balance.



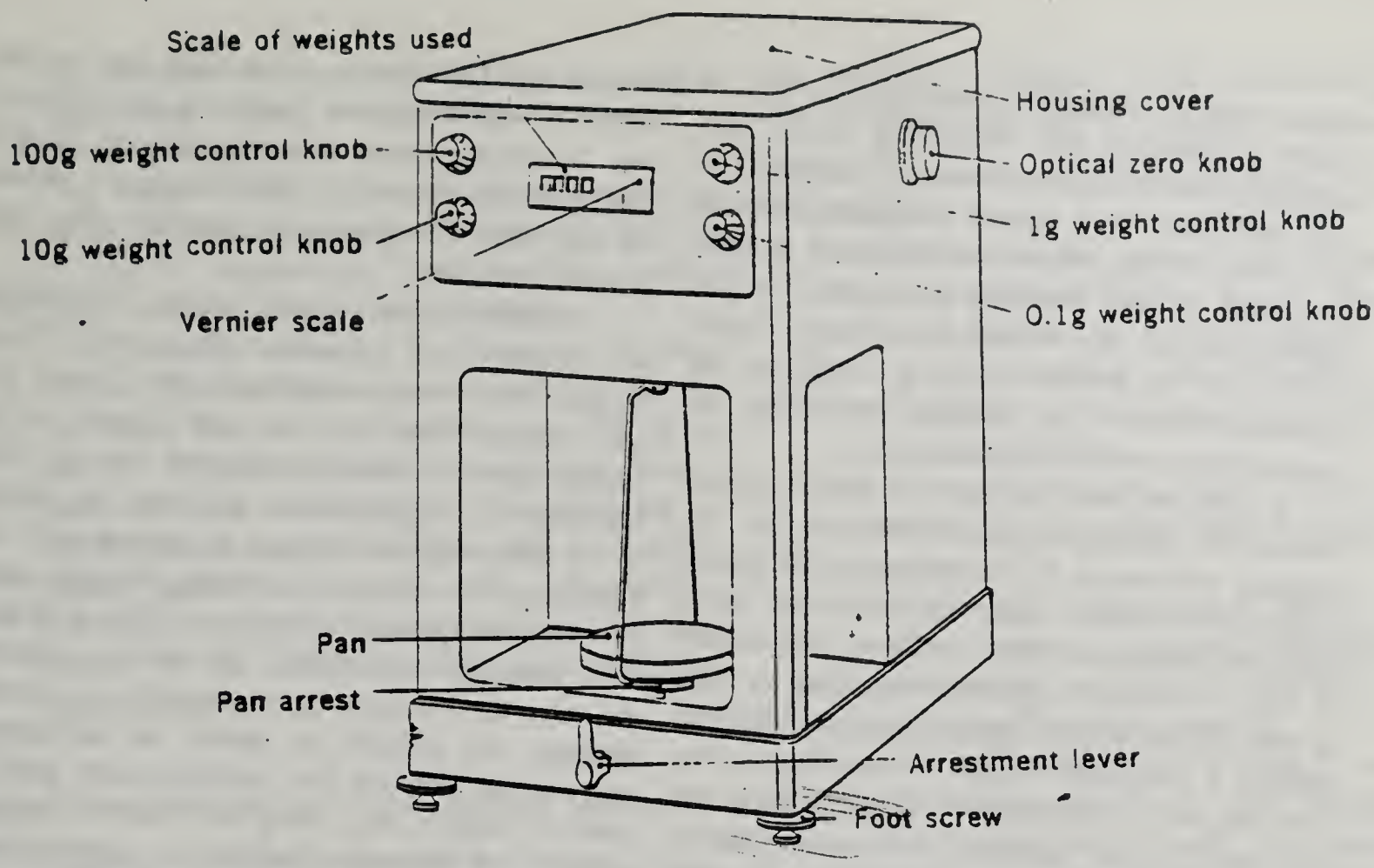


Fig. 1-9. Automatic analytical balance.

various degrees of automatic operation. In this discussion analytical balances are divided into two types: manually operated analytical (Fig. 1-8) and automatic analytical (Fig. 1-9) balances. Each company that manufactures analytical balances has its own special name for each of the various automatic analytical balances produced. All analytical balances are used to weigh very small amounts of substances with a high degree of accuracy, but just how this is accomplished differs slightly from one balance to another. Some require little or no manual operation, and some are more time-consuming and require much more manipulation on the part of the operator. Some of the fine analytical balances manufactured for use in the clinical laboratory are the Ainsworth, Voland, Gram-atic, Christian-Becker, Mettler, and Sartorius balances. Others are also available. It is important to investigate carefully several different analytical balances before deciding on one for use in a particular laboratory.

As stated previously, almost every procedure performed in the laboratory depends on the use of balances, the most important one being the analytical balance. Before any procedure is started, reagents must be prepared and standard solutions made. Standard solutions are always very accurately prepared, and the analytical balance is used to weigh the chemicals for these solutions. The analytical balance might be called the starting point of each method used in the laboratory. Its accuracy determines the accuracy of many clinical determinations. An instrument that is so sensitive and so essential must be made with great skill and treated very carefully by those using it.

The analytical balance should be cleaned and adjusted at least once a year to ensure its continued accuracy and sensitivity. Its accuracy is what makes this instrument so essential in the clinical laboratory. The accuracy to which most analytical balances used in the clinical laboratory

should weigh chemicals is commonly 0.1 mg, or 0.0001 g. Whenever this accuracy is needed, the analytical balance must be used. Differences between automatic and manual analytical balances lie mainly in the manner in which the weights are added in the weighing procedure. In the manual balance the weights are actually placed on one of the balance pans by hand. In the automatic balance the weights are added by manipulating a series of dials.

It is essential that the parts of the analytical balance be thoroughly understood, so that the weighing process can be carried out to the degree of accuracy necessary. Once the correct use of an analytical balance has been mastered, one should be able to use any of the available types, as they all have the same basic parts. Each manufacturer supplies a complete manual of operating directions, as well as information on the general use and care of the balance, with each balance purchased. These directions should be followed closely.

Basic parts

1. *Glass enclosure.* The analytical balance is enclosed in glass to prevent currents of air and collection of dust from disturbing the process of weighing.

2. *Balancing screws.* Before doing any weighing on the balance, it must be properly leveled. This is done by observing the leveling bubbles, or spirit level, located near the bottom of the balance. If necessary, adjust the balancing screws located on the bottom of the balance case (usually found on each leg of the balance).

3. *Beam.* This is the structure from which the pans are suspended.

4. *Knife edges.* These support the beam at the fulcrum during weighing and give sensitivity to the balance. Knife edges are vital parts and are constructed of hard metals to give a minimum amount of friction.

5. *Pans for weighing.* In the manually operated analytical balance, there are two pans: the weights are placed on the right-hand pan and the object to be weighed is placed on the left-hand pan. In the automatic analytical balance, there is only one pan. The object to be weighed is placed on this pan. The pans are suspended from the ends of the beam.

6. *Weights.* In the manual balance, the weights are found in a separate weight box. These weights are never handled with the fingers but are removed from the box and placed on the balance pan by using ivory-tipped forceps. Mishandling of weights, either by using the fingers or by dropping, can result in an alteration of the actual and true mass of the weight. Weights come in units ranging from a 50-g to a 100-mg weight. The values of the weights are stamped directly on top of them. In the automatic analytical balance, the weights are inside the instrument and are not seen by the operator unless there is need to remove the casing for repair or adjustment. The weights are added by manipulating specific dials calibrated for the weighing process. The built-in weights are on the same end of the beam as the sample pan and are counterbalanced by a fixed weight at the opposite end; they are removed from above the pan when an object is weighed. There is always a constant load on the beam, and the projected scale has the same weight regardless of the load. The total weight of an object is registered automatically by a digital counter or in conjunction with an optical scale.

7. *Pan arrest.* This is a means of arresting the pan so that sudden movement or addition of weights or chemical will not injure the delicate knife edges. The pan arrests (usually found under the pans) can absorb any shock due to weight inequalities, so that the knife edges are not subjected to this shock. The pan must be released to swing freely during actual weighing. In the automatic analytical balance the arresting mechanism for both the pan and the beam is operated by a single lever. Partial release or full release can be obtained, depending on how the lever is moved.

8. *Damping device.* This is necessary to arrest

the swing of the beam in the shortest practical time, thus cutting down the time consumed in the weighing process.

9. *Vernier scale.* This is the small scale used to obtain precise readings to the nearest 0.1 mg. It is used in conjunction with the large reading scale to obtain the necessary readings.

10. *Reading scale.* In the manual analytical balance, this scale is actually the reading scale for the chain that is used for weighing 100 mg or less. It is used in conjunction with the vernier scale to obtain readings to the nearest 0.1 mg. In the automatic analytical balance, this is usually a lighted optical scale, giving a high magnification and sharp definition for easier reading. The total weight of the object in question is registered automatically on this viewing scale.

General rules for use of the analytical balance

Weighing errors will occur if the balance is not properly positioned. It is therefore very important that the balance be located and mounted in an optimal position. The balance must be level. This is usually accomplished by adjusting the movable screws on the legs of the balance. The firmness of support is also important. The bench or table on which the balance rests must be rigid and free from vibrations. Preferably the room in which the balance is set up should have constant temperature and humidity. Ideally, the analytical balance should be in an air-conditioned room. The temperature factor is most important. The balance should not be placed near hot objects such as radiators, flames, stills, or electric ovens. Likewise, it should not be placed near cold objects, especially not near an open window. Sunlight or illumination from high-power lamps should be avoided in choosing a good location for the analytical balance.

The analytical balance is a delicate precision instrument, which will not function properly if abused. When learning to use an analytical balance, students should make themselves responsible for knowing and adhering to the rules for the use of the particular balance with which they are provided. The following general rules apply:

1. Set up the balance where it will be free from vibration.
2. Load and unload the balance only when the pans are arrested; if the pans are not arrested, the delicate knife edges can be damaged.
3. Close the balance case before observing the reading; any air currents present would affect the weighing process.
4. Never weigh any chemical directly on the pan; a container of some type must be used for the chemical.
5. Never place a hot object on the balance pan. If an object is warm, the weight determined will be too light because of convection currents set up by the rising heated air.
6. Whenever the shape of the object to be weighed permits, handle it with tongs or forceps. Round objects such as weighing bottles may be handled with the fingers, but take care to prevent weight changes caused by moisture from the hand. Do not hold any object longer than necessary.
7. On completion of weighing, remove all objects and clean up any chemical spilled on the pans or within the balance area. Close the balance case.
8. Weighed materials should be transferred to labeled containers or made into solutions immediately.

Speed in weighing is obtained only through practice.

Procedure for weighing with a manual analytical balance

1. Sitting directly in front of the center of the balance, dust off the pans and the inside of the balance with a soft brush.

2. Check to see that the balance is level by observing the leveling bubbles. Make any necessary adjustment by means of the leveling screws on the legs of the balance.

3. To adjust the balance to a beginning reading of zero, lower the beam and release the pan arrests, making certain that the chain reading scale and the vernier scale are both set at zero. Note where the pointer comes to rest, and slowly move the chain until the pointer rests exactly at zero. Arrest the pans and raise and lock the beam. Recheck by repeating these same steps once again. The pointer should still rest exactly at zero. By use of the vernier scale adjustment knob, adjust the zero of the vernier scale to match the zero of the chain reading scale.

4. With the beam raised and locked and the pans arrested, place the weighing vessel on the left-hand pan, using tongs if possible.

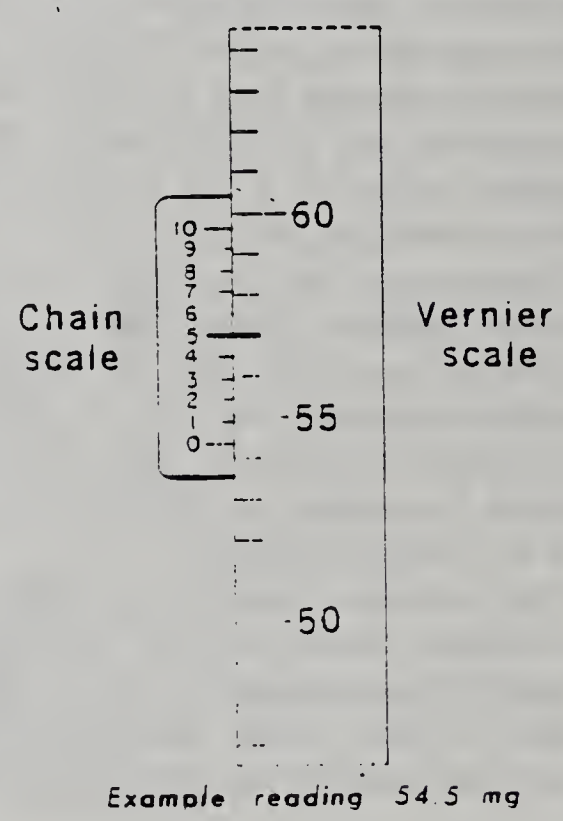
5. From the box of weights provided with the balance, transfer the first weight to the right-hand pan, using the special forceps. Choose a rather large weight as the first weight: 20-g weight would be satisfactory for most purposes. Lower the beam and release the pan arrests. Note where the pointer swings in relation to the zero point. If the pointer swings to the left, the weight is heavier than the vessel. If the pointer swings to the right, the weight is lighter than the vessel. Arrest the pans, and raise and lock the beam.

6. Depending on the direction of the pointer's swing in the previous step, either add another weight from the box of weights, or remove the 20-g weight and replace it with a lighter one (10 g). Repeat this process by adding and removing weights (being certain to raise and lock the beam and arrest the pans before each change of weights) until the addition of the smallest weight in the box (100 mg) causes the pointer to swing to the left. Close the balance window.

7. At this point add weight from the chain. The chain has a total weight of 100 mg and is used when no further weights from the box can be used. With the beam locked and the pans arrested, add 50 mg from the chain by moving the chain scale adjustment knob. Lower the beam and release the pans. Observe the pointer. Again, if the pointer swings to the left the chain weight is too light, and more weight must be added. Raise the beam and arrest the pans. Depending on the swing of the pointer, either add weight by moving the chain by 20-mg steps until the addition of 20 mg causes the pointer to swing to the left, or remove weight by 20-mg steps until the pointer swings to the right. When the chain weight has been narrowed down to within 10 mg of true balance, leave the beam lowered and the pans released, and gradually add or remove weight until balance is obtained. The weighing vessel has now been weighed, and the actual weighing of the desired chemical can commence. Record the weights used to obtain balance with the weighing vessel. To obtain the reading to the nearest 0.1 mg, the vernier scale (Fig. 1-10) must be used in conjunction with the chain scale. Raise the beam and arrest the pans.

8. To the weight of the weighing vessel add the amount of chemical to be weighed. For example, if the weighing vessel weighs 35.5646 g and the amount of chemical to be weighed is 10.5555 g, the total weight is 46.1201 g. This total weight should be on the right-hand pan. To

Fig. 1-10. Reading obtained with a vernier scale.



accomplish this, add the necessary weights from the box of weights and the chain scale to make up the difference.

9. Add the chemical in small amounts, using a clean spatula until balance is achieved. Before each addition of chemical raise the beam and arrest the pans. When balance is obtained, the amount of chemical has been weighed in the weighing vessel. Then transfer it quantitatively to a flask for dilution (see under Quantitative Transfer).

10. Return all weights to the box, return the chain to zero, and clean up any spilled chemical from the balance area. Leave the beam in a raised and locked position, and arrest the pans.

Procedure for weighing with an automatic analytical balance

1. Before doing any weighing, make certain that the balance is properly leveled. Observe the spirit level (leveling bubble), and adjust the leveling screws on the legs of the balance if necessary.

2. To check the zero point adjustment, fully release the balance and turn the adjustment knob clockwise as far as it will go. The optical scale zero should indicate three divisions below zero on the vernier scale. Using the same adjustment knob, adjust the optical scale zero so that it aligns exactly with the zero line on the vernier scale. Arrest the balance.

3. With the balance arrested, place the weighing vessel on the pan, using tongs if possible, so that no humidity or heat is brought into the weighing chamber by the hands. Close the balance window.

4. Weigh the vessel in the following manner: partially release the balance and turn the 100-g weight control knob clockwise. When the scale moves up, turn the knob back one step. Repeat this operation with the 10-g, 1-g, and 0.1-g knobs, in that order. Arrest the balance. After a short pause, release the balance, and allow the scale to come to rest. Read the result and arrest the balance. With the balance arrested, unload the pan and bring all knobs back to zero.

5. Add the weight of the sample desired to the weight of the vessel just weighed to get the total to be weighed. Set the knobs (100, 10, 1, and 0.1 g) to the correct total weight needed. When the 0.1-g knob has been set at its proper reading, the balance should be placed in partial release. Slowly add the chemical to the vessel until the optical scale begins to move downward. When the optical scale starts downward, fully release the beam, and continue to add the chemical until the optical scale registers the exact position desired. To obtain the reading to the nearest 0.1 mg (the sensitivity of most analytical balances), the vernier scale must be used in much the same manner as in the manual analytical balance readings.

6. With the balance arrested, unload the pan, and bring all the knobs back to zero. Clean up any spilled chemical in the balance area.

Torsion balance

These balances are used mainly for weighing chemicals in the laboratory. They are sensitive, responsive instruments with an exceptionally long service life, during which there is no significant deterioration in performance. In normal use, they require very little maintenance. The unique attributes of the torsion balance movement, which is assembled as a single flexible structure by means of highly tensed torsion bands of watch-spring alloy, eliminate the use of knife edges, bearings, and other loose parts that would become dull, misaligned, and soiled. Having no knife edges to dull or other loose parts to be adjusted accounts for the popularity of the torsion balance. Little or no adjustment is required, and this is important in a laboratory, where the time element is so important.

The torsion balance has high sensitivity under a heavy load, permits fast weighing, and is relatively inexpensive. Care must be taken to avoid

overloading these balances. Some models have a dial-controlled torque spring to eliminate the use of smaller loose weights. Other models are offered with dial-controlled built-in weights, which may further reduce the number of loose weights required. Many weighing determinations can be completed in about one-fifth the time formerly required. A sliding tare weight is provided to counterbalance the weighing vessel used. The beam is operated by a lever on the balance case. Some torsion balances are enclosed completely in glass or metal cases. Several of these balances have a damping feature, which brings the balance to equilibrium quickly. One such damping device is an oil dashpot, which is filled at the factory with silicon oil. Weighing can be done more rapidly on torsion balances with damping devices than on those lacking them.

There is usually a means by which the torsion balance can be arrested. This need only be done when the balance is to be moved to a new location or otherwise transported.

The sensitivity of the torsion balance varies with the model chosen. For most clinical laboratories, however, balances with a sensitivity of readings to the nearest 0.01 g are satisfactory. The manufacturer supplies a complete manual with directions for setting up, proper use, and care of the particular torsion balance. These directions should be followed closely.

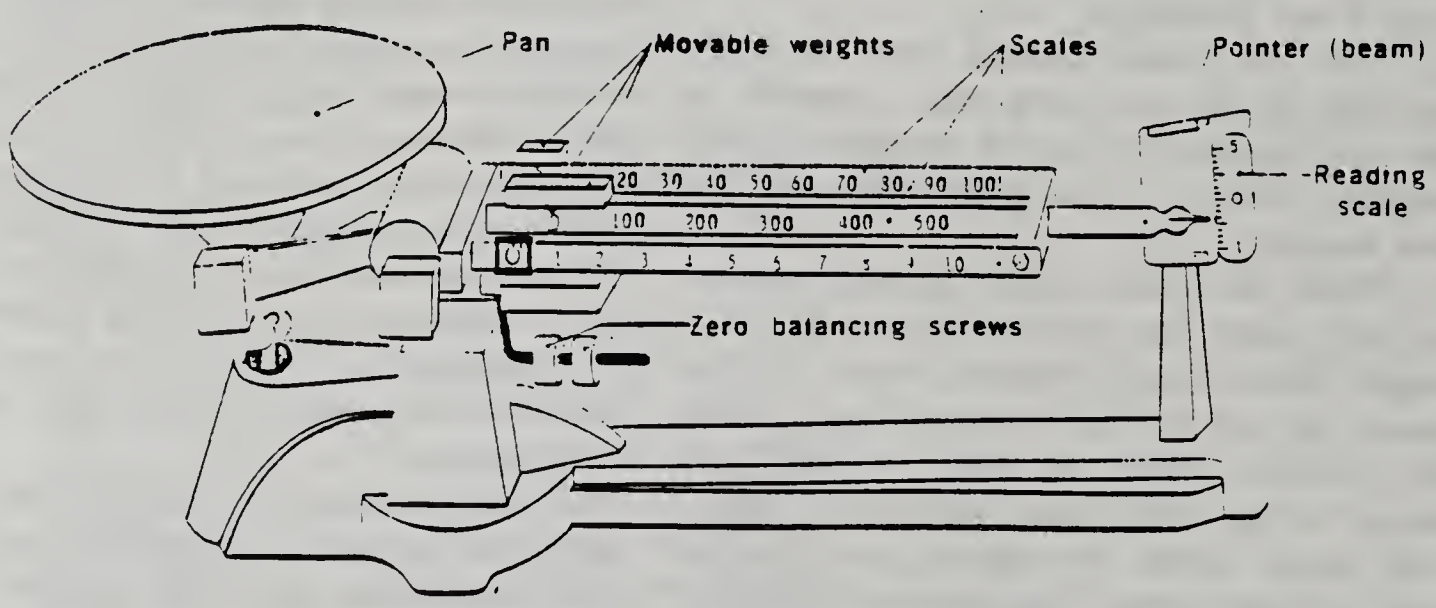
Procedure

1. Check to be sure that the balance is level, and adjust the leveling screws if necessary.
2. Check the zero adjustment. The optical reading scale should read zero with the pan empty and clean; adjust the optical zero with the small control knob if necessary.
3. Place the weighing vessel on the pan. Turn the weight control knob until the optical reading scale reads zero.
4. Add the chemical to the vessel until the desired weight registers on the optical scale. A vernier scale is present on most models so that the weight may be read to the accuracy needed. Torsion balances used in clinical laboratories have an accuracy of either 0.1 or 0.01 g.
5. Remove the vessel with the weighed chemical from the pan. Turn the control knob to zero, and wipe up any spilled chemical immediately.

Triple-beam balance

Another common piece of laboratory apparatus used for weighing is the triple-beam or "trip" balance (Fig. 1-11). This is a less sensitive balance with accuracy to the nearest 0.1 g. Whenever reagents are to be prepared with an accuracy

Fig. 1-11. Triple-beam balance.



of 0.1 g or less, the triple-beam balance can be used most satisfactorily. As the words triple-beam and trip suggest, three beams are present on the balance. Each beam provides a different weighing scale. Scales reading from 0 to 100 g, 0 to 500 g, and 0 to 10 g are usually provided on the triple-beam balance. These scales are provided with movable weights. The two larger scales have weights that lock into accurately milled notches at each calibration to ensure absolute accuracy at each position.

Some models of the triple-beam balance (called the *Harvard triple-beam* balance) have two pans, and some have a single pan. The principle of the weighing process is the same whether there are two pans or only one. Two-pan balances are used when two objects must be balanced against each other, as in balancing tubes for use in the centrifuge. One-pan balances are used a great deal in the laboratory for preparing reagents and chemical solutions.

Some type of less sensitive balance such as the triple-beam or torsion balance is an essential piece of equipment for every clinical laboratory, as many reagents are prepared that do not need the accuracy of the analytical balance. When an accuracy of more than 0.1 g is not needed, the triple-beam balance can be used. It can be operated simply and rapidly and gives accurate weighings when used properly. Even a balance with less sensitivity must be used carefully and according to the directions provided with the particular model.

The triple-beam balance should be placed on a reasonably flat and level surface. The beam should be near zero balance, with all the movable weights at their zero points. A final zero balance is attained by adjusting the balancing screws. It is advisable to check the zero balance periodically, especially if the balance has been moved. If an object is to be weighed, the balance must be set at zero before the weighing is begun. If a vessel is weighed in preparation for the addition of a chemical, it is not necessary to set the balance at the exact zero reading.

Basic parts

1. *Pan.* This is where the object or weighing vessel holding the substance to be weighed is placed.
2. *Beam.* The beam is a lever supported by a knife plane bearing at the center post. The length of beam to the right of the knife plane is graduated for placement of a sliding weight and ends in a pointer. The other end of the beam is attached to the pan guide with a knife edge contact.
3. *Movable weights or poises.* These are sliding weights attached to the beam that are moved to bring the balance into equilibrium. The trip balance has three beams, and various weight increments are added as the poises are advanced toward the pointer ends of the beams.
4. *Reading scale.* This is a scale located at the end of the beam pointer that shows when the balance is in equilibrium.
5. *Balancing screws or spindle.* This is a pair of threaded weights that are used to bring the empty balance into equilibrium.

Procedure for general use

1. Place the weighing vessel on the balance pan without previously bringing the balance to zero.
2. With the weighing vessel on the pan, bring the balance to zero by adjusting the movable weights on the three scales. Record the sum of the weights required for balance.
3. To the recorded weight add the amount of chemical to be weighed. For example, if the reagent to be prepared requires 10.5 g of NaCl and the weighing vessel weighs 35.5 g, the total weight is 46.0 g. Move the movable weights on the scales to give this total weight.
4. Gradually add the chemical until the pointer of the balance rests exactly at the zero mark on the vertical reading scale. Remove the weighing vessel and return the movable weights to their zero positions. Transfer the chemical quantitatively to the flask for dilution.

5. Wipe up any spilled chemical immediately from the balance area.

A special type of triple-beam balance is known as the *Cent-O-Gram* balance. This balance also has three beams, but they are tiered on three levels, so that the readings can be obtained from a single eye level. The three beams on the Cent-O-Gram balance provide different weighing scales. The center beam is graduated to 10 g in 1-g notches. As the name implies, the sensitivity of this balance is the nearest 0.01 g. The Cent-O-Gram balance has a lever for arresting the balance when placing objects on the pan.

On any type of triple-beam balance, the balance position of an object on the pan can be determined by observing the swing of the pointer. A swing of an equal number of divisions on either side of the zero mark on the dial indicates that the scale is balanced. It is not necessary to wait for the oscillation to stop to determine the correct weight. This observation enables the weighing process to be a simple and rapid one.

JOB SHEET

002E-001-001

"REVIEW TYPES OF BALANCES AND THEIR USES"

SELECT THE BEST ANSWER.

1. The "backbone" of the clinical chemistry laboratory is the:

   A. triple-beam balance.
   B. torsion balance.
   C. weighing balance.
   D. analytical balance.

2. _____ are used to weigh the chemicals and to prepare the many chemical solutions needed in the laboratory.

   A. Scales
   B. Balances
   C. Cent-o-grams
   D. Weights

3. _____ balances are used to weigh small amounts of substances with a high degree of accuracy, but just how this is accomplished differs slightly from one balance to another.

   A. Triple-beam
   B. Cent-o-gram
   C. Torsion
   D. Analytical

4. Standard solutions are always very accurately prepared and the _____ balance is used to weigh the chemicals for these solutions.

   A. analytical
   B. triple-beam
   C. torsion
   D. cent-o-gram

5. The analytical balance should be cleaned and adjusted at least _____ _____ to ensure its continued accuracy and sensitivity.

   A. once a week
   B. once a month
   C. once every 6 months
   D. once a year

6. In the manual balance the weights are actually placed on one of the balance pans by _____, and in the automatic balance the weights are added by manipulating a series of _____.

   A. knife edges, screws.
   B. hand, dials.
   C. dials, hands.
   D. beams, dials.

7. Before doing any weighing on the balance, it must be properly

   A. leveled.
   B. controlled.
   C. handled.
   D. understood.

8. In the manually operated analytical balance, there are two pans: the _____ are placed on the right-hand pan, and the _____ to be weighed is placed on the left-hand pan.

   A. object, weights
   B. weights, object
   C. solutions, substances
   D. substances, solutions

9. In the manual balance, the weights are never handled with the fingers but are removed from the box and placed on the balance pan by using ivory-tipped _____.

   A. applicators.
   B. forceps.
   C. handles.
   D. knives.

10. Any air currents present would affect the _____ process.

   A. balancing
   B. adjusting
   C. leveling
   D. weighing

11. To adjust a manual analytical balance to a beginning reading of zero, lower the beam and release the pan arrests, making certain that the chain reading scale and the vernier scale are both set at _____.

   A. 0.
   B. 0.1 mg.
   C. 10 mg.
   D. 20 mg.

12. _____ balances are used mainly for weighing chemicals in the laboratory.

    A. Triple-beam
    B. Torsion
    C. Analytical
    D. Cent-o-gram

13. Whenever reagents are to be prepared with an accuracy of 0.1 g or less, the _____ balance can be used most satisfactorily.

    A. triple-beam
    B. torsion
    C. analytical
    D. cent-o-gram

14. This balance has three beams tiered on three levels so that the readings can be obtained from a single eye level.

    A. Cent-o-gram
    B. Triple-beam
    C. Torsion
    D. Analytical

15. This is the small scale on an analytical balance which is used to obtain precise readings to the nearest 0.1 mg.

    A. Reading
    B. Vernier
    C. Zero
    D. Chain

INTERMEDIATE OBJECTIVE #2

DEMONSTRATE USE OF BALANCES.

LEARNING STEPS (Activities)	RESOURCES
1. Observe Resource #1 for a demonstration on use of balances.	1. See instructor.
2. Complete Resource #2 for practice using balances.	2. Job Sheet 002E-002-001, "Practice Using Balances," Pages 16 & 17, in this SLG.
3. When you feel you have mastered this task, complete Resource #3 for a final performance.	3. Performance Checklist #002E pg. 18, in this SLG. See instructor for evaluation.
4. Complete Resource #4 for a written evaluation.	4. Written Criterion Exam #002E, in the LRC. See LRC Secretary. See instructor for evaluation.
5. Proceed to Resource #5.	5. See instructor for next learning guide.

JOB SHEET

002E-002-001

"PRACTICE USING BALANCES"

DIRECTIONS TO THE STUDENT:

GIVEN THE NECESSARY SUPPLIES AND EQUIPMENT, PRACTICE USING BALANCES.

NECESSARY SUPPLIES AND EQUIPMENT:
- Analytical balance
- Triple-beam balance
- Weighing vessel
- Tongs
- Chemical
- Flask

PROCEDURE:

AUTOMATIC ANALYTICAL BALANCE

1. Level balance.
2. Check zero point adjustment.
3. Arrest the balance.
4. Place weighing vessel on the pan.
5. Close the balance window.
6. Weigh the vessel.
7. Read the result.
8. Arrest the balance.
9. Unload the pan.
10. Bring all knobs back to zero.
11. Add total weight.
12. Add slowly, chemical to vessel.
13. Arrest the balance.
14. Unload the pan.
15. Bring knobs back to zero.
16. Clean up.

JOB SHEET

002E-002-001 (Cont'd)

"PRACTICE USING BALANCES"

TRIPLE-BEAM BALANCE

1. Place weighing vessel on balance pan.
2. Bring balance to zero.
3. Record the sum of weights.
4. Add amount of chemical to be weighed.
5. Obtain total weight.
6. Add chemical until at zero mark.
7. Transfer chemical to flask.
8. Clean up.

PERFORMANCE/PRODUCT CHECKLIST

Program: MEDICAL ASSISTING

Task No: 002E

Student's Name: _____ Date Of Attempt: _____

Evaluator's Name: _____ Evaluation Site: _____

Performance Attempt: 1 2 3 4

Terminal Performance Objective:

Given the necessary tools and equipment, demonstrate use of balances.

Directions To The Student:

Before attempting this task for mastery, carefully review this checklist. You will be evaluated on the basis of this checklist. When you feel you are ready for evaluation, contact your instructor. You must complete your performance within 10 minutes and must score at least 24 out of 24 points or 100 % for mastery. Critical items are marked with an asterisk (*). These items must be satisfactorily completed.

Directions To The Evaluator:

The student will contact you when ready for the evaluation. The student must complete the performance within 10 minutes and must score 24 out of 24 points or 100 % and all items marked with an asterisk (*) must be satisfactorily completed.

CRITICAL ITEMS	ITEMS TO BE OBSERVED OR CHECKED	RATING YES	RATING NO
	AUTOMATIC ANALYTICAL BALANCE		
*	1. Level balance.		
*	2. Check zero point adjustment.		
*	3. Arrest the balance.		
*	4. Place weighing vessel on the pan.		
*	5. Close the balance window.		
**	6. Weigh the vessel.		
*	7. Read the result.		
*	8. Arrest the balance.		
*	9. Unload the pan.		
*	10. Bring all knobs back to zero.		
*	11. Add total weight.		
*	12. Add slowly, chemical to vessel.		
*	13. Arrest the balance.		
*	14. Unload the pan.		
*	15. Bring knobs back to zero.		
*	16. Clean up.		
	TRIPLE-BEAM BALANCE		
*	17. Place weighing vessel on balance pan.		
*	18. Bring balance to zero.		
*	19. Record the sum of weights.		
*	20. Add amount of chemical to be weighed.		

SEE NEXT PAGE

TOTAL POINTS EARNED =

POINTS NEEDED FOR MASTERY =
TOTAL POINTS POSSIBLE =

CRITICAL ITEMS	ITEMS TO BE OBSERVED OR CHECKED	RATING YES	RATING NO
*	21. Obtain total weight.		
*	22. Add chemical until at zero mark.		
*	23. Transfer chemical to flask.		
*	24. Clean up.		

TOTAL POINTS EARNED =

POINTS NEEDED FOR MASTERY = 24
TOTAL POINTS POSSIBLE = 24

PROGRAM MEDICAL ASSISTING

CRITERION EXAM

TASK = 002E

DIRECTIONS:

THE PURPOSE OF THIS EXAM IS TO DETERMINE WHETHER OR NOT YOU HAVE UNDERSTOOD THE INFORMATION ON DEMONSTRATING USE OF BALANCES.

Each of the questions or incomplete statements below is followed by several words, phrases, or a series of numbers. Choose the one which best answers the question or completes the statement correctly. Place the letter associated with that choice (A,B,C or D) in the numbered blank space on your ANSWER SHEET. DO NOT WRITE ON THIS TEST!!! To master this exam you must answer 14 out of 15 items correctly, 90 %.

EVALUATION SHEET

WRITTEN CRITERION EXAMINATION

TASK #002E

"DEMONSTRATE USE OF BALANCES"

1. Standard solutions are always very accurately prepared and the _____ balance is used to weigh the chemicals for these solutions.

   A. analytical
   B. triple-beam
   C. torsion
   D. cent-o-gram

2. In the manual balance, the weights are never handled with the fingers, but are removed from the box and placed on the balance pan by using ivory-tipped _____.

   A. applicators.
   B. forceps.
   C. handles.
   D. knives.

3. This is the small scale on an analytical balance which is used to obtain precise readings to the nearest 0.1 mg.

   A. Reading
   B. Vernier
   C. Zero
   D. Chain

4. The "backbone" of the clinical chemistry laboratory is the _____ _____.

   A. triple-beam balance.
   B. torsion balance.
   C. weighing balance.
   D. analytical balance.

5. Before doing any weighing on the balance, it must be properly _____.

   A. leveled.
   B. controlled.
   C. handled.
   D. understood.

6. This balance has three beams tiered on three levels so that the readings can be obtained from a single eye level.

   A. Cent-o-gram
   B. Triple-beam
   C. Torsion
   D. Analytical

7. Any air currents present would affect the _____ process.

   A. balancing
   B. adjusting
   C. leveling
   D. weighing

8. _____ balances are used to weigh small amounts of substances with a high degree of accuracy, but just how this is accomplished differs slightly from one balance to another.

   A. Triple-beam
   B. Cent-o-gram
   C. Torsion
   D. Analytical

9. To adjust a manual analytical balance to a beginning reading of zero, lower the beam and release the pan arrests, making certain that the chain reading scale and the vernier scale are both set at _____.

   A. 0.
   B. 0.1 mg.
   C. 10 mg.
   D. 20 mg.

10. In the manually operated analytical balance, there are two pans: the _____ are placed on the right-hand pan, and the _____ to be weighed is placed on the left-hand pan.

   A. object, weights
   B. weights, object
   C. solutions, substances
   D. substances, solutions

11. _____ balances are used mainly for weighing chemicals in the laboratory.

   A. Triple-beam
   B. Torsion
   C. Analytical
   C. Cent-o-gram

12. _____ are used to weigh the chemicals and to prepare the many chemical solutions needed in the laboratory.

A. Scales
B. Balances
C. Cent-o-gram
D. Weights

13. The analytical balance should be cleaned and adjusted at least _____ _____ to ensure its continued accuracy and sensitivity.

A. once a week
B. once a month
C. once every 6 months
D. once a year

14. Whenever reagents are to be prepared with an accuracy of 0.1 g or less, the _____ balance can be used most satisfactorily.

A. triple-beam
B. torsion
C. analytical
D. cent-o-gram

15. In the manual balance the weights are actually placed on one of the balance pans by _____ and in the automatic balance the weights are added by manipulating a series of _____.

A. knife edges, screws.
B. hand, dials.
C. dials, hands.
D. beams, dials.

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COMPETENCY-BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

STUDENT LEARNING GUIDE

Produced By Rosemarie Meyer Date 12/84

* TASK: PERFORM PIPETTING.

*High Tech

PURPOSE: Glassware is used in all departments of the laboratory, and special types of glass apparatus have been devised for special uses. One special type of glassware (volumetric glassware) is pipets. This Learning Guide will assist you to perform pipetting.

Medical Assisting

emf

Program	Task	Est.Time	Prereq.
07.0904	003	8 hrs.	

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME _____ SOCIAL SECURITY NUMBER _____

LENGTH OF CONTRACT (NORMAL TIME IN HOURS) 8 hrs.

2. TERMINAL PERFORMANCE OBJECTIVE

Given the necessary tools and equipment, perform pipetting. To master this task you must score 4 out of 4 (100%) on a final performance and 19 out of 20 (95%) on a Written Criterion Examination.

2a. INTERMEDIATE OBJECTIVE(s)

1. Describe pipets.
2. Perform pipetting.

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____. I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

Student's Signature _____

Instructor's Signature (verifies competency) _____

INTERMEDIATE OBJECTIVE #1

DESCRIBE PIPETS.

LEARNING STEPS (Activities)

1. Read Resource #1 for information on pipets.

2. Complete Resource #2 for a review on pipets.

3. Proceed to Resource #3.

RESOURCES

1. Information Sheet 003-001-001, "Pipets," Pg. 4-10, in this SLG.

   Information taken from Basic Techniques for the Medical Laboratory by Jorgenson and Ringsrud.

2. Job Sheet 003-001-001, "Review Pipets," pg. 11-14 in this SLG.

   See instructor for evaluation.

3. IO #2, pg. 15 , in this SLG.

Volumetric glassware

Volumetric glassware must go through a rigorous process of volume calibration to ensure the accuracy of the measurements required for laboratory determinations. In very precise work it is never safe to assume that the volume contained or delivered by any piece of equipment is exactly that indicated on the equipment. The calibration process is lengthy and time-consuming; therefore the cost of volumetric glassware is relatively high compared with the cost of noncalibrated glassware (beakers, test tubes, etc.).

Volumetric flasks

Volumetric flasks are flasks with a round bulb at the bottom. This tapers to a long neck, on which the calibration mark is found. The specifications set up by the National Bureau of Standards apply to all volumetric glassware and therefore to volumetric flasks (Fig. 1-3).[7] Volumetric flasks are calibrated to contain a specific amount or volume of liquid, and therefore the letters T.C. are inscribed somewhere on the neck of the flask. There are many different sizes of volumetric flasks, for the different volumes of liquid that are used. The following are some of the sizes in which volumetric flasks can be purchased: 10, 25, 50, 100, and 500 ml, and 1 and 2 L.

Volumetric flasks have been calibrated individually to contain the specified volume. For each size of volumetric flask there are certain allowable limits within which its volume must lie. This is called the *tolerance* of the flask. All volumetric glassware has a specific tolerance, the capacity tolerance, which is dependent on the size of the glassware. For example, a 100-ml volumetric flask has a tolerance of ±0.08 ml. Conditions are controlled during the calibration of a 100-ml volumetric flask to guarantee these limits. A tolerance of ±0.08 indicates that the allowable limits for the volume of a 100-ml volumetric flask are from 99.92 to 100.08 ml. A tolerance of ±0.05 ml for a 50-ml volumetric flask indicates allowable limits ranging from 49.95 to 50.05 ml for the volume of the flask. Volumetric flasks are used in the preparation of specific volumes of reagents or laboratory solutions. They should be used with reagents or solutions at room temperature. Solutions diluted in volumetric flasks should be repeatedly mixed during the dilution so that the contents are homogeneous before they are made up to volume. In this way, errors due to the expansion or contraction of liquids during mixing are made negligible. An important factor in the use of any volumetric apparatus is an accurate reading of the meniscus level. For more information on reading a meniscus, see under General Considerations in Pipetting.

Graduated measuring cylinders

A graduated measuring cylinder is a long cylindrical piece of glassware with calibrated markings on it. Graduated cylinders are used to measure volumes of liquids when a high degree of accuracy is not essential. They can be made from plastic or polyethylene as well as from glass (Fig. 1-3). Graduated cylinders come in various sizes according to the volumes they measure: 10, 25, 50, 100, 500, and 1000 ml. A 100-ml graduated cylinder can measure 100 ml or a fraction thereof, depending on the calibration, or graduation, marks on it. Most graduated cylinders are calibrated to deliver. This will be indicated directly on the glassware by the inscription T.D. The letters T.D. can be found on many kinds of volumetric glassware, especially on the numerous kinds of pipets used in the laboratory (see under Pipets).

Graduated cylinders can be used to measure a specified volume of a liquid, such as water, in the preparation of laboratory reagents. The calibration marks on the cylinder indicate its capacity at different points. If 450 ml of water is to be measured, the most satisfactory cylinder to use would be one with a capacity of 500 ml. Graduated cylinders are not calibrated as accu-

rately as volumetric flasks. Therefore, the capacity tolerance for graduated cylinders allows a greater variation in volume. The capacity tolerance is greater for the larger graduated cylinders. A 100-ml graduated cylinder (T.D.) has a tolerance of ±0.40 ml, meaning that the allowable limits are from 99.60 to 100.40 ml.

Pipets

Pipets are another type of volumetric glassware used extensively in the laboratory. Many types of pipets are available. It is important, however, to use only pipets manufactured by reputable companies. Care and discretion should be used in selecting pipets for clinical laboratory use, since their accuracy is one of the determining factors in the accuracy of the procedures carried out. A pipet is a cylindrical glass tube used in measuring fluids. It is calibrated to deliver, or transfer, a specified volume from one vessel to another (Fig. 1-3).

Each pipet has at least one calibration or graduation mark on it, as does all volumetric glassware. A pipet is filled by using mechanical suction or an aspirator bulb. Mouth suction is never used. Strong acids, bases, solvents, or human specimens are much too potent or contaminated to risk pipetting them by mouth. Caustic liquids and some solvents are very dangerous: some destroy tissue immediately on contact. Some solvents have harmful vapors (see under Safety in the Laboratory).

For most general laboratory use, there are two main types of pipets, the volumetric (or transfer) pipet and the graduated (or measuring) pipet. They are classified according to whether they contain or deliver a specified amount. For this reason, they may be called *to-contain* or *to-deliver* pipets. A to-contain pipet is identified by inscribed letters T.C. and a to-deliver one by the letters T.D. The T.D. pipet is filled properly and allowed to drain completely into a receiving vessel. Portions of nonviscous samples, such as filtrates, serum, and standard solutions, are accurately measured by allowing the volumetric pipet to drain while it is held in the vertical position and by using only the force of gravity (see under General Pipetting Procedure). For most volumetric glassware the temperature of calibration is usually 20°C, and this is inscribed on the pipet (see under Calibration of Volumetric Glassware).

The opening (orifice) at the delivery tip of the pipet is of a certain size to give a specified length of time for drainage when the pipet is held vertically. A pipet must be held vertically to ensure proper drainage. It will not drain as fast when held at a 45° angle. The actual procedure is discussed further under Pipetting (see Pipetting Technique).

Volumetric pipets

A pipet that has been calibrated to deliver a fixed volume of liquid by drainage is known as a *volumetric* pipet, or *transfer* pipet. These pipets consist of a cylindrical bulb joined at both ends to narrow glass tubing. A calibration mark is etched around the upper suction tube, and the lower delivery tube is drawn out to a fine tip. Some important considerations concerning volumetric pipets are that the calibration mark should not be too close to the top of the suction tube, the bulb should merge gradually into the lower delivery tube, and the delivery tip should have a gradual taper. To reduce drainage errors, the orifice should be of such a size that the flow out of the pipet is not too rapid. These pipets should be made from a good-quality glass, such as Kimax or Pyrex (Fig. 1-4).

Volumetric pipets are suitable for all accurate measurements of volumes of 1 ml or more. They are calibrated to deliver the amount inscribed on them. This volume is measured from the calibration mark to the tip. A 5-ml volumetric pipet will deliver a single measured volume of 5 ml and a 2-ml volumetric pipet will deliver 2 ml. The tolerance of volumetric pipets increases with the capacity of the pipet. A 10-ml volumetric pipet will have a greater tolerance than a 2-ml

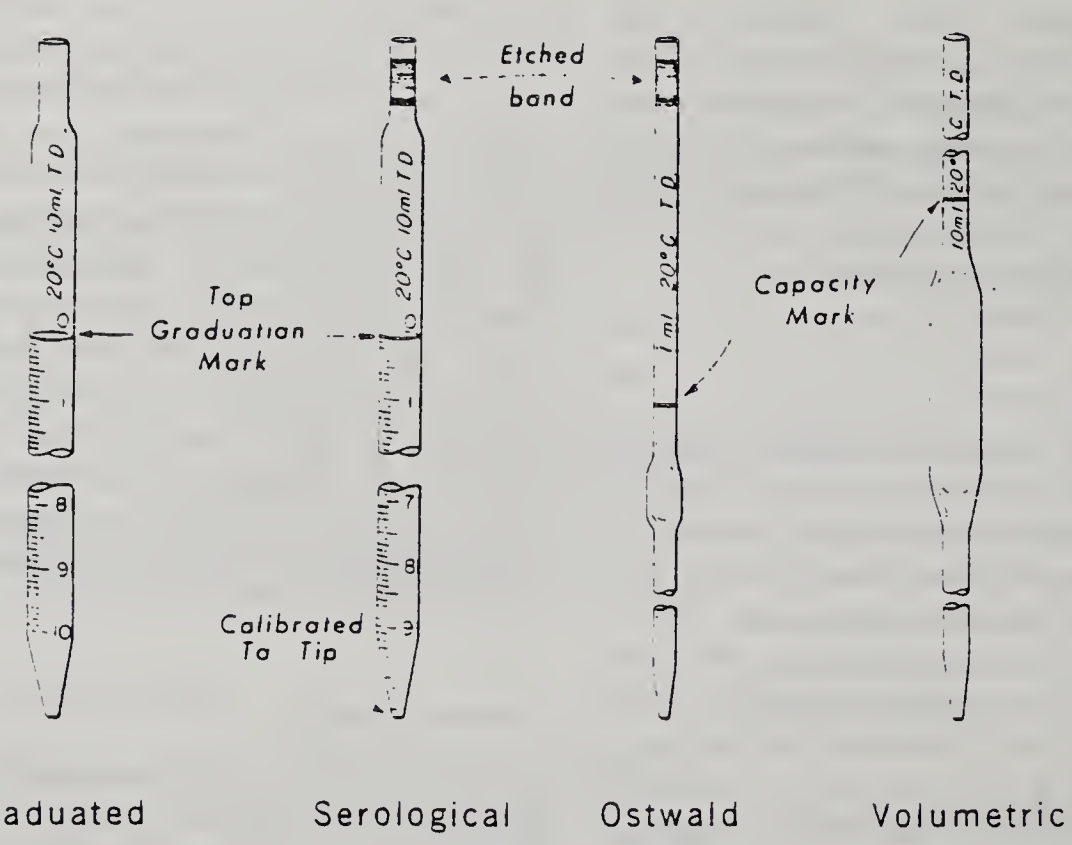

Fig. 1-4. Types of pipets.

one. The tolerance for a 5-ml volumetric pipet is ±0.01 ml. When volumes of liquids are to be delivered with great accuracy, a volumetric pipet is used. Volumetric pipets are used to measure standard solutions, unknown blood and plasma filtrates, serum, plasma, urine, spinal fluid, and some reagents.

Measurements with volumetric pipets are done individually, and the volumes can only be whole milliliters (e.g., 1, 2, 5, and 10 ml). To transfer 1 ml of a standard solution into a test tube volumetrically, a 1-ml volumetric pipet is used. To transfer 5 ml of the same solution, a 5-ml volumetric pipet is used. After a volumetric pipet drains, a drop remains inside the delivery tip. This drop is *not* to be blown out: the specific volume the pipet is calibrated to deliver is dependent on the fact that the drop is left in the tip of the pipet. Information inscribed on the pipet includes the temperature of calibration (usually 20°C), capacity, manufacturer, and usage (T.D.). The technique involved in using volumetric pipets correctly is very important, and a certain amount of skill is required (see under Pipetting Technique).

Graduated pipets

Another way to deliver a particular amount of liquid is to deliver that amount of liquid contained between two calibration marks on a cylindrical tube, or pipet. Such a pipet is called a *graduated*, or *measuring*, pipet. It has several graduation, or calibration, marks (Fig. 1-4). Many measurements in the laboratory do not require the precision of the volumetric pipet. Graduated pipets are used when great accuracy is not required. This does not mean that these pipets may be used with less care than the volumetric pipets. Graduated pipets are used primarily in measuring reagents, but they are not calibrated with sufficient tolerance to use in measuring standard or control solutions, unknown specimens, or filtrates.

A graduated pipet is a straight piece of glass tubing with a tapered end and graduation marks

on the stem separating it into parts. Depending on the size used, graduated pipets can be used to measure parts of a milliliter or many milliliters. These pipets come in various sizes or capacities, including 0.1, 0.2, 1, 2, 5, 10, and 25 ml. If 4 ml of deionized water is to be measured into a test tube, a 5-ml graduated pipet would be the best choice. Since graduated pipets require draining between two marks, they introduce one more source of error, compared with the volumetric pipets with only one calibration mark. This makes measurements with the graduated pipet less precise. Because of this relatively poor precision, the graduated pipet is used where speed is more important than precision. It is used for measurements of reagents and is generally not considered accurate enough for measuring samples and standard solutions.

Two types of pipets are calibrated for delivery (Fig. 1-4). One (called a Mohr pipet) is calibrated between two marks on the stem, and the other (a serological pipet) has graduation marks down to the delivery tip. The serological pipet has a larger orifice and therefore drains faster than the Mohr pipet (see under Serological Pipets).

The volume of the space between the last calibration mark and the delivery tip is not known in the Mohr pipet. In graduated pipets, this space cannot be used for measuring fluids. Graduated pipets are calibrated in much the same manner as volumetric pipets; however, they are not constructed with as strict specifications and they have larger capacity tolerances. The allowable tolerance for a 5-ml graduated pipet is ±0.02 ml.

To-contain pipets (micropipets)

The to-contain pipet, when used properly, is one of the more precise pipets used in the clinical laboratory. This type of pipet is calibrated to *contain* a specified amount of liquid. If a pipet contains only 0.1 ml, and 0.1 ml of blood is needed for a chemistry determination, then none of the blood can be left inside the pipet. The entire contents of the pipet must be emptied. If this pipet is *rinsed well* with a diluting solution, then all the blood or similar specimen will be removed from it. The correct way to use a to-contain pipet is to rinse it with a suitable diluent. Thus, a to-contain pipet cannot be used properly unless the receiving vessel contains a diluent; that is, a to-contain pipet should not be used to deliver a specimen into an empty receiving vessel. Since all the liquid in a to-contain pipet is rinsed out and used, there is only one graduation mark.

To-contain pipets are used when micro amounts of blood or specimen are needed, and they are also called *micropipets* in many areas of the laboratory. Many procedures require only a small amount of blood, and a micropipet is used for this measurement. Because even a minute volume remaining in the pipet can cause a significant error in micro work, most micropipets are calibrated to contain (T.C.) the stated volume rather than to deliver it. They are generally available in small sizes, such as 20, 50, 100, and 200 μl. A common micropipet used is the Sahli hemoglobin pipet, calibrated to contain 0.02 ml or 20 μl.

A special disposable micropipet used in the hematology laboratory is a self-filling pipet accompanied by a polyethylene reagent reservoir (see under Hematology). This unit is called a Unopette (Becton, Dickinson & Co., Rutherford, N.J.) and is used by many laboratories. A glass capillary pipet is fitted in a plastic holder and fills automatically with blood by means of capillary action. The plastic reagent bottle (called the reservoir) is squeezed slightly while the pipet is inserted. On release of pressure, the sample is drawn into the diluent in the reservoir. Intermittent squeezing fills and empties the pipet to rinse out the contents of the pipet. This type of unit has been adapted for several chemical and hematological determinations.

Ostwald pipets

A special type of pipet designed for use in measuring viscous fluids such as blood or serum is known as the *Ostwald* pipet (or the *Ostwald-Folin* pipet). When blood is to be measured in the chemistry laboratory, the Ostwald pipet is used. This pipet is similar in appearance to the volumetric pipet, except that the bulb is closer to the delivery tip (Fig. 1-4). Ostwald pipets are usually calibrated to be blown out, and therefore an etched ring or band will be seen near the suction hole. To minimize the effects of viscosity, the Ostwald pipet is designed with a large oval bulb and a short delivery tip.

Ostwald pipets come in several sizes; the most common ones are 0.5, 1, and 2 ml. When using an Ostwald pipet to measure blood, the blood should be allowed to drain as slowly as possible so that no residual film is left on the sides of the pipet. Contrary to the usual practice of reading the bottom of the meniscus for liquids being measured by pipet, when blood is pipetted in the Ostwald pipet, the top of the meniscus is read (blood is not transparent and the bottom of the meniscus cannot be seen clearly).

Serological pipets

Another pipet used in the laboratory, but not often in the chemistry laboratory, is called a *serological* pipet. It is much like the graduated pipet in appearance (Fig. 1-4). The orifice, or tip opening, is larger in the serological pipet than in other pipets. The rate of fall of liquid is much too fast for great accuracy or precision. For use in chemistry it would be necessary to retard the flow of liquid from the delivery tip of the serological pipet. The serological pipet is graduated to the end of the delivery tip and has an etched band on the suction piece. It is therefore designed to be blown out. The serological pipet is less precise than any of the pipets discussed above. It is designed for use in serology, where relative values are sought. It is best not to use the serological pipet for chemistry.

Stopcock pipets

The *stopcock* pipet is designed for delivering blood into a Van Slyke machine, which is used for the determination and analysis of gases such as oxygen and carbon dioxide. The stopcock pipet can be used to deliver anything that is not to be exposed to the air. It resembles a small volumetric pipet with a stopcock attached near the delivery tip; this is used for better control of the delivery of the sample into the machine. Stopcock pipets have two calibration marks, one on either side of the bulb.

Automatic pipets

Automatic and semiautomatic versions of pipets are useful in many areas of laboratory work. Use of automatic pipetting devices eliminates pipet cleaning and reduces the error resulting from the variation in pipetting techniques. Several different types are available, and each must be carefully calibrated before it is used. The problems encountered with automatic pipetting devices depend to a large degree on the nature of the solution being pipetted. Some reagents cause more bubbles than others, and some are more viscous. Each of these tendencies can cause problems with the measurement and delivery of samples and solutions.

Automatic pipetting devices permit measuring out a whole series of equal volumes. They provide very efficient delivery of equal volumes of specimens followed by equivalent volumes of diluent. These automatic devices can be operated either manually or by a motor. Since proper care and calibration are essential for accurate sampling, it is important to read and follow the manufacturer's instructions.

under Safety in the Laboratory) The pipets are allowed to soak in the cleaning solution for [illegible] minutes.

The next step involves thorough rinsing of the pipets. This can be accomplished by hand, but more often it is done with the aid of an automatic pipet washer. The pipets are rinsed with tap water, utilizing the automatic pipet washer, for 1-2 hours. They are then rinsed in deionized or distilled water two or three times and dried in a hot oven. An alternative cleaning solution is a solution of detergent. However, the acid cleaning solution is recommended.

Cleaning diluting pipets

Pipets used in the hematology laboratory for dilution are also cleaned in a special way. They should always be rinsed immediately after use, preferably by being placed in a tumbler or beaker of water until they are cleaned. There are several ways to clean these pipets, but in general they are first cleaned with tap water, then with distilled water, and finally rinsed with either alcohol or acetone. Acetone assists in drying the inside of the pipet. Usually the cleaning is done with suction, using a special pipet holder that fits onto the suction apparatus. The pipets are also dried with suction. Periodically, the pipets should be cleaned with a detergent solution, rinsed well, and dried.

Cleaning photometry cuvettes

Cuvettes must be scrupulously clean and free from grease smudges or scratches. As soon as possible after use, cuvettes should be rinsed with tap water, filled with a mild detergent solution, and placed in a rubberized test tube rack. It is best not to put them into a regular dishwashing basket where they would rub against each other and be scratched. After standing with the detergent solution, the cuvettes are rinsed several times with tap water and two or three times with distilled or deionized water. When drying cuvettes, high temperatures and unclean air should be avoided. A low to medium oven (not above 100°C) can be used for rapid drying. In some laboratories, there are special dishwashing machines that can adequately handle cuvettes.

Glass breakage and replacement

It is important in the clinical laboratory to check all glassware periodically to determine its condition. No broken or chipped glassware should be used. Many laboratory accidents are caused by the use of broken glassware. Serious cuts may result, and infections may set in.

Each time a laboratory procedure is carried out, the glassware used should be checked; equipment such as beakers, pipets, test tubes, and flasks should not have broken edges or cracks. To prevent breakage, glassware should be handled carefully; carrying too much glassware at one time from one place to another in the laboratory is to be avoided.

When glassware is broken, it must be replaced with another like piece. Breakage should be reported to an instructor or department head, so that replacement can be arranged. Several laboratory equipment catalogs are available from which the required items may be ordered. These catalogs are distributed by supply companies that handle laboratory equipment. They describe the quality, capacity, tolerance, and cost of the available items. To purchase equipment at the most reasonable price it is advisable to compare specific items in several different catalogs.

THE MICROSCOPE

The microscope is probably the piece of equipment that receives the most use (and, unfortunately, misuse) in the clinical laboratory. Microscopy is a basic part of the work in many areas

soap, detergent, or cleaning powder. In most laboratories, detergents are used. If the dirty glassware has been soaking in a solution of the detergent water, the cleaning job will be much easier.

General cleaning procedure

There are various specific methods of cleaning laboratory glassware. Most glassware (with the exception of pipets) can be cleaned in the following way.

1. Put the specified amount of detergent into a dishpan or washing bucket containing moderately hot water. Allow the detergent to dissolve thoroughly.

2. Rinse glassware (or other items that can be washed) in tap water before placing it in the detergent solution. Never allow dirty glassware to dry out; always place it in a soaking bucket. Glassware should be completely submerged in the bucket or pan. Fill large pieces with detergent water and set aside to soak. Soaking glassware for at least 1 hour before washing makes the washing procedure much more efficient.

3. Using a cleaning brush, thoroughly scrub the glassware, being certain to clean all parts. Brushes of various sizes should be available to fit the different-sized test tubes, flasks, funnels, and bottles. Excessive brushing and improper use of brushes may cause scratching of the glassware. Avoid the use of abrasive cleaners on glassware.

4. Rinse glassware under running tap water; allow the water to run into each piece of glassware, pour it out, and repeat several times (7-10 times is sufficient). Rinse the outside of the glassware too. It is especially important to *remove all the detergent from the glassware before use*; if detergent remains, the alkali in it may interfere with laboratory determinations.

5. After thoroughly rinsing the glassware with tap water, rinse it with distilled or deionized water about three times. Certain glassware used for microbiological studies requires even longer rinsing with deionized water. Use deionized or distilled water in the final rinsing of all laboratory glassware.

6. Glassware may be dried in a hot oven (no hotter than 100°C) or at room temperature. If a higher temperature is used, the glassware can become distorted. Always dry glassware or other equipment in an inverted position to ensure complete drainage of water as it dries. Never dry laboratory ware with a towel. Do not dry plastic-ware or rubber items in an oven.

7. Check the glassware for cleanliness by observing the water drainage. Chemically clean glassware will drain uniformly; dirty glassware will drain leaving water droplets adhering to the walls of the glass.

Clearing pipets

Pipets used in the laboratory are cleaned in a special way. Immediately after use, the pipets should be placed in a special pipet container or cylinder containing water; the water should be high enough to completely cover the pipets. Pipets should be carefully placed in the container to avoid breakage. When the pipets are to be cleaned, they are removed from the cylinder and placed in another cylinder containing an acid cleaning solution. This cleaning solution is usually a combination of sulfuric acid and either potassium or sodium dichromate (called acid-dichromate solution). Acid-dichromate cleaning solution may be purchased commercially, or it may be prepared by dissolving 100 g of sodium or potassium dichromate in 100 ml of water and slowly adding, while stirring, the contents of one 9-lb bottle of technical grade sulfuric acid. For safe handling during the preparation, the container of acid solution should be placed in a pan or sink of cold water because of the great amount of heat generated on mixing the acid and water. Safety goggles should always be worn during the preparation of this solution, as should rubber gloves and a protective apron. It is an extremely potent solution, and it must be handled cautiously or serious burns will result (see

JOB SHEET 003-001-001

"REVIEW PIPETS"

SELECT THE BEST ANSWER.

1. A cylindrical glass tube used in measuring fluids and calibrated to deliver, or transfer, a specified volume from one vessel to another is a _____.

   A. pipet
   B. flask
   C. cylinder
   D. buret

2. A _____ is filled by using mechanical suction or an aspirator bulb.

   A. pipet
   B. flask
   C. cylinder
   D. buret

3. _____ suction is never used because strong acids, bases, solvents, or human specimens are too potent or contaminated to pipet by mouth.

   A. Mechanical
   B. Bulb
   C. Mouth
   D. Automatic

4. For most general laboratory use, there are two main types of pipets:

   A. volumetric, graduated.
   B. graduated, volumetric.
   C. micropipets, ostwald.
   D. serological, automatic.

5. A to-contain pipet is identified by inscribed letters _____ and to-deliver one by the letters _____.

   A. T.C., T.D.
   B. T.D., T.C.
   C. V.P., G.P.
   D. G.P., V.P.

6. For most volumetric glassware the temperature of calibration is _____ and this is inscribed on the pipet.

   A. $5^{o}C$
   B. $10^{o}C$
   C. $20^{o}C$
   D. $25^{o}C$

7. Volumetric flasks, pipets, graduated cylinders, and burets are examples of _____.

   A. containers.
   B. receivers.
   C. plasticware.
   D. glassware.

8. A pipet must be held _____ to ensure proper drainage.

   A. horizontal
   B. vertical
   C. parallel
   D. diagonal

9. A volumetric pipet calibrated to deliver a fixed volume of liquid by drainage is a _____ pipet.

   A. graduated
   B. transfer
   C. serological
   D. measuring

10. Volumetric pipets are suitable for all accurate measurements of volumes of _____ or more.

   A. 1 ml.
   B. 2 ml.
   C. 5 ml.
   D. 10 ml.

11. A measuring pipet delivers that amount of liquid contained between two calibration marks on a cylindrical tube. This is a _____ pipet.

   A. graduated
   B. serological
   C. volumetric
   D. automatic

12. To-contain, or _____, pipets are used when micro amounts of blood or specimen are needed.

   A. Ostwald
   B. transfer
   C. micro
   D. Mohr

"REVIEW PIPETS" (Cont'd)

13. A special type of pipet designed for use in measuring viscous fluids such as blood or serum is the _____ pipet.

    A. Stopcock
    B. graduated
    C. volumetric
    D. Ostwald

14. Another pipet used in the laboratory for use in serology is _____

    A. serological.
    B. graduated.
    C. volumetric.
    D. measuring.

15. The pipet used for the determination and analysis of gases such as oxygen and carbon dioxide is _____

    A. Ostwald-Folin.
    B. measuring.
    C. Stopcock.
    D. serological.

16. With automatic and semi-automatic versions of pipets it is important to read and follow the manufacturer's instructions and _____ before it is used.

    A. wash
    B. standardize
    C. rinse
    D. calibrate

17. Immediately after use, the pipets should be _____ in an acid-dichromate solution or detergent solution and rinsed well.

    A. washed
    B. cleaned
    C. rinsed
    D. stirred

18. _____ and correct first-aid procedures cannot be over-emphasized to anyone working in the medical laboratory.

    A. Common Sense
    B. OSHA
    C. Labeling
    D. Safety

19. Use caution when _____ any specimen from a patient.

    A. handling
    B. pipetting
    C. preparing
    D. collecting

20. Wear _____ when preparing reagents with strong chemicals such as dichromate acid cleaning solution used to clean laboratory glassware.

    A. sterile gloves
    B. safety goggles
    C. lab apron
    D. lab coat

INTERMEDIATE OBJECTIVE #2

PERFORM PIPETTING.

LEARNING STEPS (Activities)	RESOURCES
1. Observe Resource #1 for a demonstration on pipetting using different types of pipets.	1. See instructor.
2. Complete Resource #2 for identification of pipets.	2. Job Sheet 003-002-002, "Identify Pipets," pg. 16 , in this SLG.
3. Complete Resource #3 for practice on pipetting.	3. Job Sheet 003-002-003, "Pipetting," Pg. 17 , in this SLG.
4. When you feel you have mastered this task, complete Resource #4 for a performance evaluation.	4. Performance checklist Task # 003 "Perform Pipetting," Pg. 19 , in this SLG. See instructor for evaluation.
5. Complete Resource #5 for a written evaluation.	5. Written Criterion Exam, "Perform Pipetting," Task # 003, in the LRC. See LRC Secretary.
6. Proceed to Resource #6 for the next learning guide.	6. See instructor.

JOB SHEET

003-002-002

"IDENTIFY PIPETS"

A. Place one pipet of each kind in the lab on the table.

B. Refer to the Resource information in this learning guide and Scientific Products or Fischer or catalogs as such located in the Medical Assisting Lab.

C. Make a poster pasting pictures of each pipet and giving a full description of each.

D. Laminate for protection.

JOB SHEET

003-002-003

"PIPETTING"

DIRECTIONS TO THE STUDENT:

Given the necessary tools and equipment, perform pipetting.

NECESSARY TOOLS AND EQUIPMENT:

Volumetric Pipet
Graduated Pipet
Serological Pipet
Micropipet

Whole Blood or Water
Test Tubes on Vacutainer
(With Water) (With Whole Blood)
Rack
Suction Bulb

PROCEDURE:

1. Place test tubes upright in a test tube rack on vacutainer tubes.
2. Read procedure manual for individual pipet procedures.
3. Fill the pipet with blood or water (whatever instructor has available).
4. Throw away vacutainer tubes in proper receptacle.
5. Clean test tubes.
6. Clean working area.
7. Wash hands.

PERFORMANCE/PRODUCT CHECKLIST

Program: MEDICAL ASSISTING

Task No: 003

Student's Name: _____ Date Of Attempt: _____

Evaluator's Name: _____ Evaluation Site: LCAVC

Performance Attempt: 1 2 3 4

Terminal Performance Objective:

GIVEN THE NECESSARY TOOLS AND EQUIPMENT, PERFORM PIPETTING.

Directions To The Student:

Before attempting this task for mastery, carefully review this checklist. You will be evaluated on the basis of this checklist. When you feel you are ready for evaluation, contact your instructor. You must complete your performance within 10 minutes and must score at least 4 out of 4 points or 100 % for mastery. Critical items are marked with an asterisk (*). These items must be satisfactorily completed.

Directions To The Evaluator:

The student will contact you when ready for the evaluation. The student must complete the performance within 10 minutes and must score 4 out of 4 points or 100 % and all items marked with an asterisk (*) must be satisfactorily completed.

CRITICAL ITEMS	ITLMS TO BE OBSERVED OR CHECKED	RATING YES	RATING NO
*	1. Wash hands.		
*	2. Pipet with pipets given to you by your instructor.		
*	3. Clean up working area and test tubes.		
*	4. Store in proper place.		

TOTAL POINTS EARNED =

POINTS NEEDED FOR MASTERY = 4
TOTAL POINTS POSSIBLE = 4

PROGRAM MEDICAL ASSISTING

CRITERION EXAM

TASK = 003

DIRECTIONS:

THE PURPOSE OF THIS EXAM IS TO DETERMINE WHETHER OR NOT YOU HAVE UNDERSTOOD THE INFORMATION ON PIPETTING.

Each of the questions or incomplete statements below is followed by several words, phrases, or a series of numbers. Choose the one which best answers the question or completes the statement correctly. Place the letter associated with that choice (A,B,C or D) in the numbered blank space on your ANSWER SHEET. DO NOT WRITE ON THIS TEST!!! To master this exam you must answer 19 out of 20 items correctly, 95 %.

WRITTEN CRITERION EXAMINATION

"PERFORM PIPETTING"

SELECT THE BEST ANSWER.

1. _____ and correct first-aid procedures cannot be overemphasized to anyone working in the medical laboratory.

   A. Common sense
   B. OSHA
   C. Labeling
   D. Safety

2. A volumetric pipet calibrated to deliver a fixed volume of liquid by drainage is a _____ pipet.

   A. graduated
   B. transfer
   C. serological
   D. measuring

3. A cylindrical glass tube used in measuring fluids and calibrated to deliver, or transfer, a specified volume from one vessel to another is a _____.

   A. pipet
   B. flask
   C. cylinder
   D. buret

4. Wear _____ when preparing reagents with strong chemicals such as dichromate acid cleaning solution used to clean laboratory glassware.

   A. sterile gloves
   B. safety goggles
   C. lab apron
   D. lab coat

5. A to-contain pipet is identified by inscribed letters _____ and to-deliver one by the letters _____.

   A. T.C., T.D.
   B. T.D., T.C.
   C. V.P., G.P.
   D. G.P., V.P.

6. Volumetric flasks, pipets, graduated cylinders, and burets are examples of _____.

   A. containers.
   B. receivers.
   C. plasticware.
   D. glassware.

WRITTEN CRITERION EXAMINATION (Cont'd)

"PERFORM PIPETTING"

7. Use caution when _____ any specimen from a patient.

   A. handling
   B. pipetting
   C. preparing
   D. collecting

8. The pipet used for the determination and analysis of gases such as oxygen and carbon dioxide is _____.

   A. Ostwald-Folin.
   B. measuring.
   C. Stopcock.
   D. serological.

9. _____ suction is never used because strong acids, bases, solvents, or human specimens are too potent or contaminated to pipet by mouth.

   A. Mechanical
   B. Bulb
   C. Mouth
   D. Automatic

10. A measuring pipet delivers that amount of liquid contained between two calibration marks on a cylindrical tube. This is a _____ pipet.

    A. graduated
    B. serological
    C. volumetric
    D. automatic.

11. A pipet must be held _____ to ensure proper drainage.

    A. horizontal
    B. vertical
    C. parallel
    D. diagonal

12. Another pipet used in the laboratory for use in serology is _____.

    A. serological.
    B. graduated.
    C. volumetric.
    D. measuring.

WRITTEN CRITERION EXAMINATION (Cont'd)

"PERFORM PIPETTING"

13. A _____ is filled by using mechanical suction or an aspirator bulb.

    A. pipet
    B. flask
    C. cylinder
    D. buret

14. Immediately after use, the pipets should be _____ in an acid-dichromate solution or detergent solution and rinsed well.

    A. washed
    B. cleaned
    C. rinsed
    D. stirred

15. For most general laboratory use, there are two main types of pipets:

    A. volumetric, graduated.
    B. graduated, volumetric.
    C. micropipets, ostwald.
    D. serological, automatic.

16. Volumetric pipets are suitable for all accurate measurements of volumes of _____ or more.

    A. 1 ml.
    B. 2 ml.
    C. 5 ml.
    D. 10 ml.

17. A special type of pipet designed for use in measuring viscous fluids such as blood or serum is the _____ pipet.

    A. Stopcock
    B. graduated
    C. volumetric
    D. Ostwald

18. For most volumetric glassware the temperature of calibration is _____ and this is inscribed on the pipet.

    A. 5°C
    B. 10°C
    C. 20°C
    D. 25°C

WRITTEN CRITERION EXAMINATION (Cont'd)

"PERFORM PIPETTING"

19. To-contain, or _____, pipets are used when micro amounts of blood or specimen are needed.

    A. Ostwald
    B. transfer
    C. micro
    D. Mohr

20. With automatic and semi-automatic versions of pipets, it is important to read and follow the manufacturer's instructions and _____ before it is used.

    A. wash
    B. standardize
    C. rinse
    D. calibrate

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COMPETENCY-BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

STUDENT LEARNING GUIDE

Produced By Rosemarie Meyer, RN, CMA Date 10/11/84

TASK: OPERATE CENTRIFUGE

PURPOSE: AS A LABORATORY WORKER YOU WILL BE EXPECTED TO KNOW WHY AND HOW TO OPERATE EACH TYPE OF EQUIPMENT IN THE LABORATORY. THIS ENSURES PROPER PROCEDURE AND SAFE OPERATION. THIS LEARNING GUIDE WILL ASSIST YOU IN OPERATING A CENTRIFUGE.

MEDICAL ASSISTING

Program	Task	Est.Time	Prereq.
07.0904	004	4 HRS.	

edk

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME _____ SOCIAL SECURITY NUMBER _____

LENGTH OF CONTRACT (NORMAL TIME IN HOURS) 4 hours

2. TERMINAL PERFORMANCE OBJECTIVE

Given a centrifuge and necessary tools, you will operate a centrifuge. To master this task you must score 5 out of 6 (90%) on a performance checklist and 14 out of 15 (90%) on a written criterion examination.

2a. INTERMEDIATE OBJECTIVE(s)

1. Describe centrifuge.
2. Operate centrifuge.

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____. I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

Student's Signature _____

Instructor's Signature (verifies competency) _____

Program	Task	Page
07.0904	004	1

INTERMEDIATE OBJECTIVE #1

Describe centrifuge.

LEARNING STEPS (Activities)

1. Read Resource #1 for information on centrifuge.
2. Complete Resource #2 for a review on the centrifuge.
3. Proceed to Resource #3.

RESOURCES

1. Information Sheet 004-001-001, "Use of the Centrifuge", pages 3-7, in this SLG.
2. Job Sheet 004-001-002, "Review Centrifuge", pages 8 - 10 in this LSG.
3. MPO #2, page 11 , in this SLG.

USE OF THE CENTRIFUGE

Taken from textbook:

BASIC TECHNIQUES FOR THE MEDICAL LABORATORY

by: J. Linne and K Ringsrud

CENTRIFUGES

Taken from textbook:

MOSKY'S FUNDAMENTALS OF MEDICAL ASSISTING

by: M. Shea and S. Zakus

USE OF THE CENTRIFUGE

Centrifugation is used in the separation of a solid material from a liquid. It is also used in recovering solid materials from suspensions, as in the microscopic examination of urine. The solid material or sediment packed at the bottom of the centrifuge tube is sometimes called the precipitate, and the liquid or top portion is called the supernatant. Another important use for the centrifuge is in the separation of serum or plasma from cells in blood specimens. The suspended particles, solid material, or blood cells usually collect at the bottom of the centrifuge tube because the particles are heavier than the liquid. Occasionally the particles are lighter than the liquid and will collect on the surface of the liquid when centrifuged. Centrifugation is employed in every department of the clinical laboratory, in chemistry, urinalysis, hematology, and

blood banking, among others. Proper use of the centrifuge is important for anyone engaged in laboratory work.

Centrifuges facilitate the separation of particles in suspension by the application of centrifugal force. Several types of centrifuges will usually be found in the same laboratory, each designed for special uses. There are table-model and floor-model centrifuges, some small and others very large; there are even refrigerated centrifuges for special procedures.

Directions for use of a centrifuge are most frequently given in terms of speed, or revolutions per minute (r/min). A rheostat is used to set the desired speed: the setting on the rheostat dial does not necessarily correspond directly to revolutions per minute. The setting speeds on the rheostat can also change with variations in weight load and general aging of the centrifuge.

The top speed of most conventional centrifuges is about 3000 r/min. The microhematocrit centrifuge used in many hematology laboratories for packing red blood cells attains a speed of about 10 000 r/min.

Two types of centrifuges are used in doing routine laboratory determinations. One is a conventional horizontal centrifuge and the other is an angle head centrifuge. For the horizontal-type centrifuge, the cups holding the tubes of material to be centrifuged occupy a vertical position when the centrifuge is at rest, but assume a horizontal position when the centrifuge revolves. For the angle head centrifuge, the cups are held in a rigid position at a fixed angle. This position makes the process of centrifuging more rapid than it is with the horizontal centrifuge. There is also less chance that the sediment will be disturbed when the centrifuge stops. Both types of centrifuges may be purchased as table or floor models.

The most important rule to remember in using any centrifuge is: *always balance the tubes placed in the centrifuge.* That is, in the centrifuge cup opposite the material to be centrifuged, place a container of equivalent size and shape with an equal volume of liquid of the same specific gravity as the load. For most laboratory determinations, water may be placed in the balance load.

Special centrifuge tubes should be used. These are tubes constructed to withstand the force exerted by the centrifuge. They have thicker glass walls or are made of a stronger, more resistant glass. Some of these tubes are conical, and some have round bottoms. Some are disposable and others must be washed.

Before placing the centrifuge tubes in the cups or holders, check the cups to make certain that the rubber cushions are in place. If some cushions are missing, the centrifuge will not be properly balanced. Without the cushions, the tubes are more likely to break.

Whenever a tube breaks in the centrifuge cup, it is most important that both the cup and the rubber cushion in the cup be cleaned well to prevent further breakage by glass particles left behind.

Covers specially made for the centrifuge should be used except in certain specified instances. Using the cover prevents possible danger from flying glass should tubes break in the centrifuge. Keep the centrifuge cover closed at all times, even when not using the machine. In addition to the danger from broken glass, using the centrifuge without the cover in place may cause the revolving parts of the centrifuge to vibrate, which causes excessive wear of the machine.

Do not try to stop the centrifuge with your hands. It is generally best to let the machine stop by itself. A brake may be applied if the centrifuge is equipped with one. The brake should be used with caution, as braking may cause some resuspension of the sediment. Many laboratories discourage use of the brake except where it is evident that a tube or tubes have broken in the centrifuge.

Centrifuges should be checked, cleaned, and lubricated regularly to ensure proper operation.

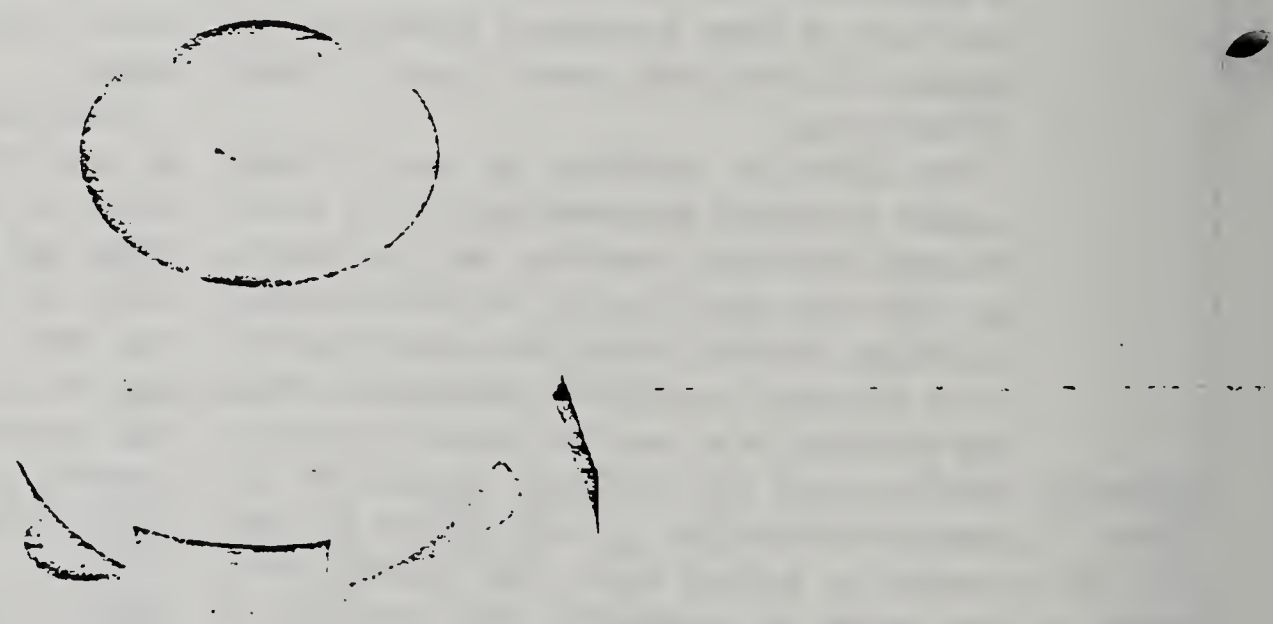
Centrifuges

Centrifuges are motorized devices that rotate at a high speed (Figures 23.3 and 23.4). The speed is stated as *revolutions per minute (rpm)*. Centrifuges are used to separate components of varying densities contained in liquids by spinning them at high speeds. Through centrifugal (moving away from a center) force, heavier or solid components move to the lower part of the container, and the lighter substances move to the upper part of the container. By this process the two substances, solid material and fluid supernatant, are separated.

Centrifuges are used in every department of a clinical laboratory. In a physician's office or health care agency, centrifuges will be used if a microscopic analysis of urine is performed and also when serum is required for hematology or blood chemistry laboratory tests.

There are numerous types of centrifuges available. Each must be selected according to the intended use. Centrifuges commonly used in a physician's office or clinic are table models. One type is used for routine blood and urine separations (Figure 23.3), and

Figure 23.3
Centrifuge used for blood and urine separations.



another type is used for microhematocrit applications (Figure 23.4). The speed at which these centrifuges operate varies from 3,200 rpm for the routine blood and urine separations to 11,500 to 15,000 rpm for the microhematocrit centrifuges. Special centrifuge tubes should be used in the centrifuges for serum or urine separations. These tubes are either conical or round-bottomed in shape and made of a special quality glass. Some Vacutainer tubes used for blood collection may also be put into the centrifuge. Capillary tubes are to be used in the microhematocrit centrifuges. It is important that you always use tubes that are the correct size and strength for the required application.

In the centrifuge there are special centrifuge cups with rubber cushions that are used to hold the tubes containing the blood or urine samples. Be certain that the cushions are at the bottom of the holders before you place the tubes into them.

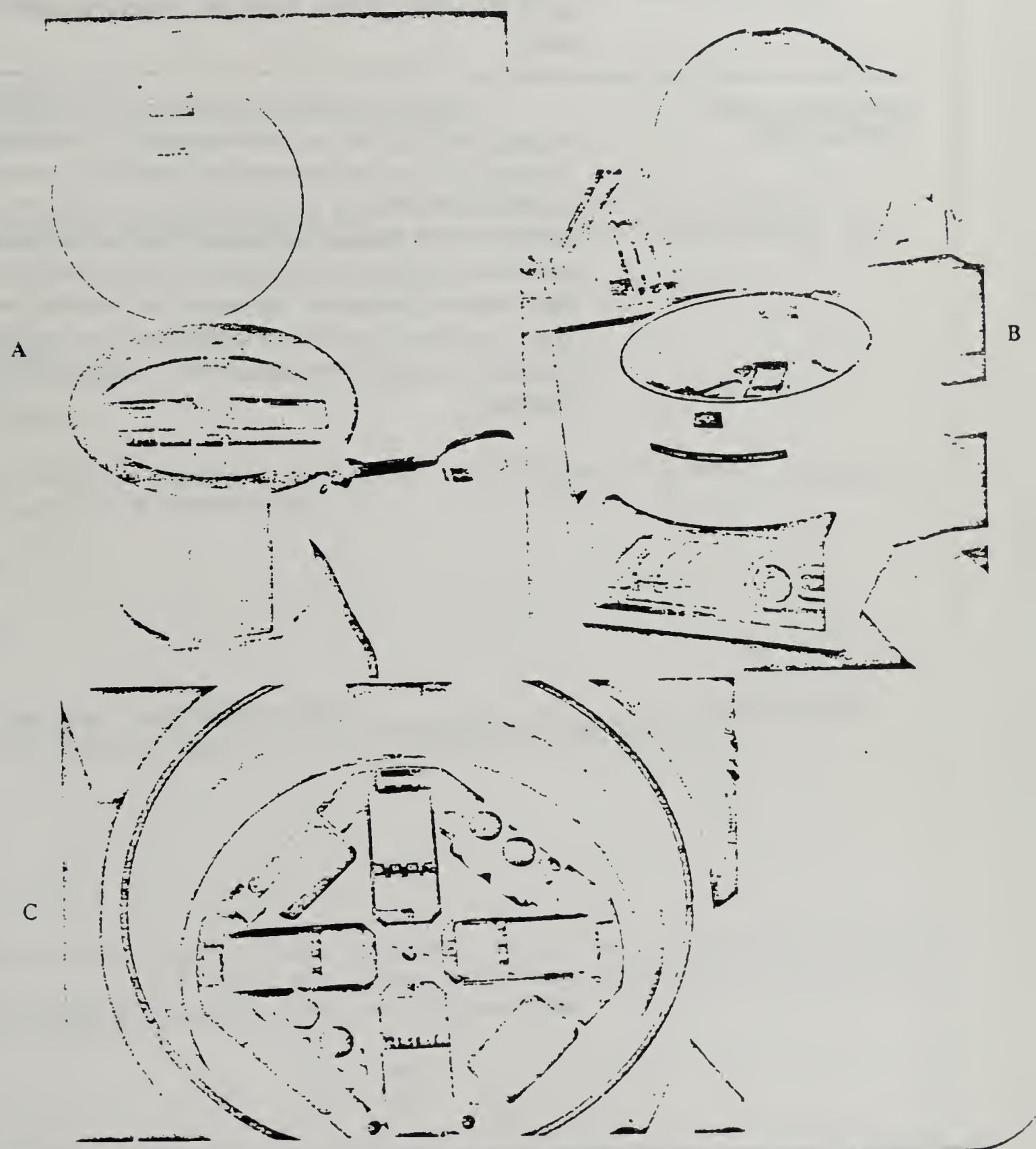


Figure 23.4
A and B. Centrifuges used for microhematocrit applications. C. View inside TRIAC centrifuge. Capillary tubes will be placed inside numbered columns.

PLACEMENT OF TUBES IN THE CENTRIFUGE

When you place a tube containing a specimen into the centrifuge you must counterbalance it with a tube of similar design and weight. This other tube must be placed directly opposite the tube containing the specimen and should contain a liquid of equal weight. Water can usually be used for this purpose. If you do not balance the load in a centrifuge, severe vibration of the centrifuge may occur and you may possibly lose the specimens. *Do not* use tubes that are cracked or badly scratched, because they may break under the stress of the centrifugal force. If breakage does occur, immediately turn the centrifuge off. Don rubber gloves and clean the centrifuge cushion and cup. You must clean these areas before using the centrifuge again to avoid additional breakage of tubes.

OPERATING THE CENTRIFUGE

When you operate the centrifuge you must close the cover. (Many newer models will not work if you do not close the cover.) If you are using an older model centrifuge, *do not* open the cover until the rotor has completely stopped. *Do not* brake sharply when using centrifuges that operate with hand brakes. Always use tubes that are the correct size and strength for the required application. Electrical appliances such as the centrifuge should have three-pronged grounding plugs, and there should be sufficient grounded outlets available. Frequent lubrication, calibration, and cleaning are required for the proper operation of all centrifuges. Specific instructions for operating each centrifuge are provided by the manufacturer. Read these instructions completely and carefully before you operate any centrifuge.

JOB SHEET

004-001-002

Select the BEST answer.

1. The separation of a solid material from a liquid, the recovering of solid materials form suspensions, and the separation of serum or plasma from cells in blood specimens is

   A. extraction.
   B. diffusion.
   C. centrifugation.
   D. pipetting.

2. Although the setting on the dial does not necessarily correspond directly to R/min., the _____ is used to set the desired speed.

   A. dial
   B. push-button
   C. knob
   D. rheostat

3. In the _____ centrifuge, the cups are held in a rigid position at a fixed angle making the process of centrifuging more rapid.

   A. horizontal
   B. angle head
   C. vertical
   D. conventional

4. An important rule to remember in using a centrifuge is always _____ the tubes placed in a centrifuge.

   A. even off
   B. weigh
   C. balance
   D. look at

5. For most laboratory determinations, _____, having the same specific gravity, may be used to balance a load.

   A. blood
   B. urine
   C. liquid
   D. water

6. In addition to the danger of broken glass, using the centrifuge without the _____ in place may cause revolving parts of the centrifuge to vibrate, causing excessive wear of the machine.

   A. top
   B. cover
   C. cord
   D. cap

7. Do not try to stop the centrifuge with your _____ and use the brake with caution.

   A. friend
   B. hands
   C. handle
   D. dial

8. Centrifuge should be checked, cleaned, and lubricated _____to ensure proper operation.

   A. daily
   B. weekly
   C. monthly
   D. regularly

9. Before operation of a centrifuge check the _____directions and be instructed on its proper use. (SAFETY COUNTS).

   A. procedural
   B. posted
   C. safety
   D. manufacturer's

10. Through centrifugal force, _____components move to the lower part of the container, and the _____move to the upper part of the container.

   A. lighter, heavier
   B. heavier, lighter
   C. fluid, solid
   D. solid, fluid

11. _____tubes are to be used in the microhematocrit centrifuges.

   A. Capillary
   B. Vacutainer
   C. Correct-sized
   D. Cushioned

12. Special centrifuge cups with rubber_____are used to hold the tubes containing the blood or urine samples and are at the bottom of the holders before you place the tubes in them.

   A. suctions
   B. cushions
   C. stoppers
   D. tubes

13. If breakage of tubes does occur, _____ turn off the centrifuge and don rubber gloves to clean the centrifuge cushion and cup.

    A. eventually
    B. immediately
    C. gradually
    D. hurriedly

14. If braking is necessary, brake

    A. gently.
    B. immediately.
    C. sharply.
    D. timely.

15. Electrical appliances such as a centrifuge should have three-pronged _____ plugs, and there should be sufficient _____ outlets available.

    A. electrical
    B. grounded
    C. indoor
    D. wall

INTERMEDIATE OBJECTIVE #2

Operate centrifuge.

LEARNING STEPS (Activities)	RESOURCES
1. Observe Resource #1 for a demonstration of the operation of a centrifuge.	1. See instructor.
2. Refer to Resource #2 for manufacturer's directions.	2. See procedure manual in M.A. lab.
3. Complete Resource #3 for practice on operating a centrifuge.	3. Job Sheet 004-002-003, "Practice Operating a Centrifuge", page 12 in this SLG.
4. When you have mastered this task, see Resource #4 for a performance evaluation.	4. See instructor.
5. Complete Resource #5 for a written evaluation.	5. Written Criterion Examination, Task #004, "Operate Centrifuge", in LRC. See instructor for evaluation.
6. Proceed to Resource #6 for the next Learning Guide.	6. See instructor or task list.

JOB SHEET

004-002-003

"Practice Operating a Centrifuge"

Directions to the student:

Given a centrifuge by the instructor and referring to the manufacturer's directions ahead of time, practice operating the centrifuge.

Necessary tool and equipment:

Centrifuge
Test tubes or capillary tubes
Blood or urine samples

Procedure:

1. Place tubes in proper position to balance. Tubes must have equal amounts of specimen.

2. Place cover on tightly.

3. Turn to proper R/min.

4. Set time.

5. Allow centrifuge to stop completely.

6. Remove centrifuged samples.

PERFORMANCE/PRODUCT CHECKLIST

Program: MEDICAL ASSISTING

Task No: 004

Student's Name: _____ Date Of Attempt: _____

Evaluator's Name: _____ Evaluation Site: _____

Performance Attempt: 1 2 3 4

Terminal Performance Objective:

Given a centrifuge and necessary tools, you will operate a centrifuge.

Directions To The Student:

Before attempting this task for mastery, carefully review this checklist. You will be evaluated on the basis of this checklist. When you feel you are ready for evaluation, contact your instructor. You must complete your performance within 10 minutes and must score at least 5 out of 6 points or 90 % for mastery. Critical items are marked with an asterisk (*). These items must be satisfactorily completed.

Directions To The Evaluator:

The student will contact you when ready for the evaluation. The student must complete the performance within 10 minutes and must score 5 out of 6 points or 90 % and all items marked with an asterisk (*) must be satisfactorily completed.

CRITICAL ITEMS	ITLMS TO BE OBSERVED OR CHECKED	RATING YES	RATING NO
*	1. Balance tubes in centrifuge.		
*	2. Place cover of centrifuge tightly.		
*	3. Turn to proper R/min.		
*	4. Set timer.		
*	5. Allow centrifuge to stop completely.		
	6. Remove cnetrifuged samples.		

TOTAL POINTS EARNED =

POINTS NEEDED FOR MASTERY = 5
TOTAL POINTS POSSIBLE = 6

PROGRAM MEDICAL ASSISTING

CRITERION EXAM

TASK # 004

DIRECTIONS:

THE PURPOSE OF THIS EXAM IS TO DETERMINE WHETHER OR NOT YOU HAVE UNDERSTOOD THE INFORMATION ON operating centrifuge.

Each of the questions or incomplete statements below is followed by several words, phrases, or a series of numbers. Choose the one which best answers the question or completes the statement correctly. Place the letter associated with that choice (A,B,C or D) in the numbered blank space on your ANSWER SHEET. DO NOT WRITE ON THIS TEST!!! To master this exam you must answer 14 out of 15 items correctly, 90 %.

EVALUATION SHEET

Written Criterion Examination

TASK #004

"Review Centrifuge"

Select the BEST answer.

1. Centrifuge should be checked, cleaned, and lubricated _____ to ensure proper operation.

   A. daily
   B. weekly
   C. monthly
   D. regularly

2. In the _____ centrifuge, the cups are held in a rigid position at a fixed angle making the process of centrifuging more rapid.

   A. horizontal
   B. angle head
   C. vertical
   D. conventional

3. In addition to the danger of broken glass, using the centrifuge without the _____ in place may cause revolving parts of the centrifuge to vibrate, causing excessive wear of the machine.

   A. top
   B. cover
   C. cord
   D. cap

4. _____ tubes are to be used in the microhematocrit centrifuges.

   A. Capillary
   B. Vacutainer
   C. Correct-sized
   D. Cushioned

5. The separation of a solid material from a liquid, the recovering of solid materials from suspensions, and the separation of serum or plasma from cells in blood specimens is

   A. extraction.
   B. diffusion.
   C. centrifugation.
   D. pipetting.

EVALUATION SHEET (Cont.)
TASK #004
"Review Centrifuge"

6. Before operation of a centrifuge check the _____ directions and be instructed on its proper use. (SAFETY COUNTS).

   A. procedural
   B. posted
   C. safety
   D. manufacturer's

7. Although the setting on the dial does not necessarily correspond directly to R/min., the _____ is used to set the desired speed.

   A. dial
   B. push-button
   C. knob
   D. rheostat

8. Electrical appliances such as a centrifuge should have three-pronged _____ plugs, and there should be sufficient _____ outlets available.

   A. electrical
   B. grounded
   C. indoor
   D. wall

9. Special centrifuge cups with rubber _____ are used to hold the tubes containing the blood or urine samples and are at the bottom of the holders before you place the tubes in them.

   A. suctions
   B. cushions
   C. stoppers
   D. tubes

10. An important rule to remember in using a centrifuge is always _____ the tubes placed in a centrifuge.

    A. even off
    B. weigh
    C. balance
    D. look at

11. If braking is necessary, brake

    A. gently.
    B. immediately.
    C. sharply.
    D. timely.

12. Do not try to stop the centrifuge with your _____ and use the brake with caution.

    A. friend
    B. hands
    C. handle
    D. dial

13. For most laboratory determinations, _____, having the same specific gravity, may be used to balance a load.

    A. blood
    B. urine
    C. liquid
    D. water

14. Through centrifugal force, _____ components move to the lower part of the container, and the _____ move to the upper part of the container.

    A. lighter, heavier
    B. heavier, lighter
    C. fluid, solid
    D. solid, fluid

15. If breakage of tubes does occur, _____ turn off the centrifuge and don rubber gloves to clean the centrifuge cushion and cup.

    A. eventually
    B. immediately
    C. gradually
    D. hurriedly

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COMPETENCY-BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

STUDENT LEARNING GUIDE

Produced By Rosemarie Meyer, RN, CMA Date 8/84

TASK: Measure and Calculate Dosage

PURPOSE: As a Medical Assistant you will need to know about the three systems of measurements used in measuring doses of medication. You will need to know how to solve simple dosage problems and how to convert dosages from one system measurements to another. This learning guide will assist you to measure and calculate dosage.

Medical Assisting

Program	Task	Est.Time	Prereq.
07.0904	100	6 hrs	

jlk

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME _____ SOCIAL SECURITY NUMBER _____

LENGTH OF CONTRACT (NORMAL TIME IN HOURS) _____

2. TERMINAL PERFORMANCE OBJECTIVE

Given: the necessary tools and equipment

You will: Measure and calculate dosage

How well: To master this task you must score 4 out of 5 (90%) on a performance evaluation and 9 out of 10 (90%) on a written exam.

2a. INTERMEDIATE OBJECTIVE(s)

1. Describe measurement and dosage calculation.
2. Measure and calculate dosage.

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____. I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

Student's Signature _____

Instructor's Signature (verifies competency) _____

Program	Task	Page

INTERMEDIATE OBJECTIVE #1

1. Describe measurement and dosage calculation.

LEARNING STEPS (Activities)

1. Read Resource #1 for information on measurement and dosage calculation.

2. Complete resource #2 for a review on this objective.

3. Proceed to resource #3.

RESOURCES

1. Information sheet 100-001-001, "Measurement and dosage calculation" pages 3-17 , in this Student learning guide.
   (Information taken from textbook, Administering Medications by T. Bayt, Bobbs Merrill Educ. Publish. Indianapolis)

2. Activity sheet 100-001-002, "Review Measurement and Dosage Calculation, pages 18 - 19, in this guide.
   See instructor for evaluation.

3. MPO #2, page 20 , in this guide.

INFORMATION SHEET

#100-001-001

"MEASUREMENT AND DOSAGE CALCULATION"

Taken from textbook: Administering Medications by T. Bayt, Bobbs-Merrill Educ. Publish, Indianapolis

Vocabulary

apothecary: old word for pharmacist
Arabic numerals: 1, 2, 3, 4, and so on
calculation: figuring out a mathematical problem
centimeter: one-hundredth of a meter
conversion: changing from one unit of measurement to another
dosage range: set of quantities of a drug that are strong enough to produce therapeutic effects, but not so strong as to be toxic to the body
dram: 60 grains (1 fluidram = 60 minims)
equivalents: things that are equal in amount or value

formula: a mathematical rule for doing a certain kind of math problem
fraction: a mathematical way of talking about an amount that is part of a whole or a ratio between two numbers
grain: basic unit of weight in the apothecaries' system
gram: basic unit of weight in the metric system
kilogram: one thousand grams
liter: basic unit of volume in the metric system
metric: system of measurement based on the meter in which all units are multiples of ten
microgram: one-millionth of a gram
milligram: one-thousandth of a gram
milliliter: one-thousandth of a liter (same as cubic centimeter)
minim: basic unit of volume in the apothecaries' system
Roman numerals: I, II, III, IV, V, and so forth
unit: (1) basic quantity in a measurement system; (2) a way of telling the strength of hard-to-measure drugs such as antibiotics (e.g., 100,000 units of penicillin)
volume: amount of space taken up by a substance

Systems of measurement

Measurement has always been an important part of prescribing and administering medications. This is so because different amounts of a drug give different effects. Some drugs are deadly poisons, but when given in tiny amounts can help relieve disorders. Other drugs are useless for therapy unless given in large amounts.

Most drugs have a certain **dosage range**, that is, a range of quantities that can produce therapeutic effects (Figure 4-1). Doctors prescribe an amount within the dosage range depending on how strong an effect is needed and on the patient's age and physical condition. Doses less than the dosage range do not produce any therapeutic effects. Doses more than the dosage range are harmful to the body and can be fatal.

To get the drug effects they want, physicians and pharmacists through the ages have tried to make dosages very exact by measuring drugs carefully. However, they have not all used the same units of measurement. There are different measurement systems, each having their own units of weight and volume.

INFORMATION SHEET

#100-001-001

"MEASUREMENT AND DOSAGE CALCULATION"

(continued)

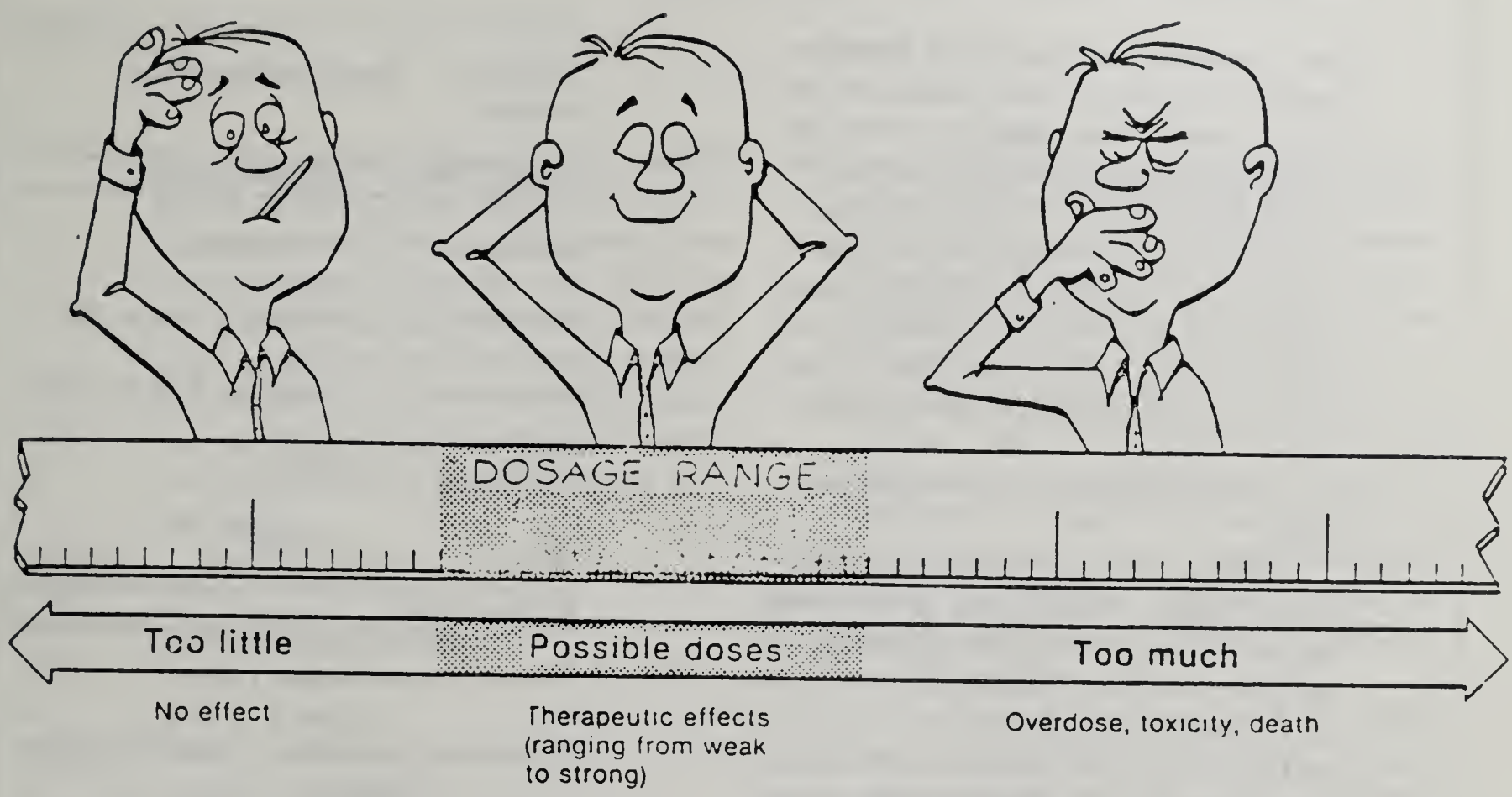


Fig. 4-1 The physician chooses a certain dose within the dosage range according to the needs of the individual patient.

Today, three different systems of measurement are commonly used in the medical field. You should be familiar with the units of weight and volume found in each system. Dosages on a medication order may be expressed in anything from milliliters or cubic centimeters to drops, teaspoons, drams, or minims. You need to know what each of these quantities means so that you can measure out the doses properly. In addition, you may be asked to convert (change) from one unit or system to another in the course of your daily routine. You need to know how to use conversion tables to convert from milligrams to grams, from milliliters to teaspoons, from grains to milligrams, and so forth.

The three systems of measurement used in ordering medications are the apothecaries' system, the metric system, and the household system.

APOTHECARIES' SYSTEM

The apothecaries' system of measurement is very old. It was brought to the United States from England during the eighteenth century. Colonial pharmacists (apothecaries) used it when compounding and measuring their medicinal preparations. The system is gradually being phased out in favor of the easier-to-use metric system, but many older physicians and patients prefer the apothecaries' system because it is more familiar to them.

The basic unit of weight in the apothecaries' system is the **grain** (gr). It was originally supposed to be the weight of one grain of wheat. The basic unit of volume is the **minim** (m). The term "volume" means the amount of space that something takes up. A minim is the space taken up by a quantity of water that weighs the same as a grain of wheat.

Table 4-1 lists all the units of weight and volume in the apothecaries' system. Note especially the abbreviations for these units. You need to be able to recognize them on a medication order and write them on a medication chart.

In the apothecaries' system, dosage quantities are written out in **lowercase Roman numerals** (see Table 4-2). The roman numerals are written *after* the unit of measurement, e.g., ℥ii meaning 2 drams.

If the quantity of units is higher than 15, Arabic numerals can be used (15, 16, 17, etc.). Arabic numerals are usually written *before* the unit of measurement.

Table 4-1 The apothecaries' system

WEIGHT (DRY)	VOLUME (LIQUID)
grain (gr)	minim (m, ♏)
dram (dr or ʒ)	fluidram (fl dr, ʒ, or fʒ)
ounce (oz or ℥)	fluidounce (fl oz, ℥, or f℥)
pound	pint (pt)
ton	quart (qt)

EQUIVALENTS

A minim of liquid weighs 1 grain

60 grains or 60 minims = 1 dram or fluidram

8 drams or fluidrams = 1 ounce or fluidounce

Table 4-2 Lower-case Roman numerals

1	i	6	vi	11	xi
2	ii	7	vii	12	xii
3	iii	8	viii	13	xiii
4	iv	9	ix	14	xiv
5	v	10	x	15	xv

(ss̄ = ½)

for example, 25 gr, although many people prefer to write them after the unit, to avoid confusing grains with grams in the metric system. Quantities less than one (½, ¾) and mixed fractions (2¾, 4½) are also usually written with Arabic numerals before the unit. The only exception is the quantity one-half, for which the symbol ss is used with roman numerals after the unit.

Here are some examples:

f℥ vii = 7 fluid ounces

ʒ iv = 4 drams

gr iss = 1½ grains

5¼ dr = 5¼ drams

$\frac{1}{150}$ gr (also gr $\frac{1}{150}$) = $\frac{1}{150}$ grain

15 gr (also gr 15) = 15 grains

30 m = 30 minims

METRIC SYSTEM

The metric system is used throughout the world and is gradually becoming accepted in the United States, especially in the field of medicine. It is a simple, logical system of measurement based on units of ten.

A unit of length, the **meter**, is the foundation of the metric system. It is actually one 10-millionth of the distance between the North Pole and the Equator. Metric volume is measured in fractions of a liter (L). Weight is measured in grams (g).

Prefixes added to the words "meter," "gram," and "liter" indicate smaller or larger units in the system (see Table 4-3). All units are a result of either multiplying or dividing by 10, 100, or 1000. The centimeter, for example, is $\frac{1}{100}$ of a meter. A millimeter is $\frac{1}{1000}$ of a meter. A kilometer is 1000 meters.

In the metric system, units of length, weight, and volume are related to each other in systematic ways. The unit of volume most often used in preparing medications is the **milliliter** (ml), which is one-thousandth of a liter. One milliliter is the liquid contents of a cube measuring 1 centimeter (cm) on a side, or 1 cubic **centimeter** (cc). One liter is the liquid contents of a cube measuring 10 cm on a side, or 1000 cc. One gram is equal to the weight of 1 ml (or cc) of water. One liter contains 1000 ml of water, and so it weighs 1000 g (1 kilogram). These relationships are shown in Figure 4-2.

Metric doses are always written out in Arabic numerals. Fractions of metric doses are written as decimal fractions. For example, one-half gram is 0.5 g. In reading medication orders, pay special attention to where the decimal point is

Table 4-3 Prefixes in the metric system

GREEK (MULTIPLY)	LATIN (DIVIDE)
deca → × 10	deci → ÷ 10
hecto → × 100	centi → ÷ 100
kilo → × 1000	milli → ÷ 1000
	micro → ÷ 1,000,000

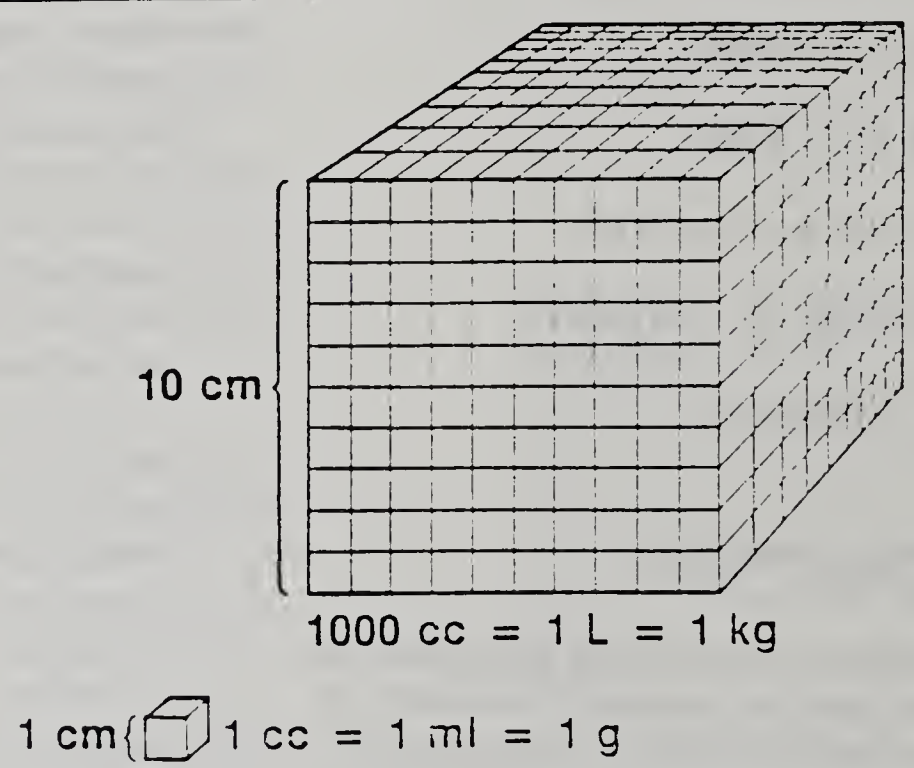


Fig. 4-2 Relationships among units of length, volume, and weight in the metric system.

placed. The differences between 0.05 g, 0.5 g, and 5.0 g are huge when it comes to doses of medicine. A mistake could be dangerous.

Table 4-4 lists the basic units of volume and weight in the metric system and their equivalents. The bottom of the table shows how to change from milligrams to grams and vice versa. Note especially the instructions, because these are simple conversions you will probably make often on the job. The conversions are easy if you remember the hints shown in Table 4-4.

HOUSEHOLD SYSTEM

The household system of measurement is actually more complicated than the metric and apothecaries' systems. However, most of us have grown up using its basic units—feet, inches, miles, pints, quarts, pounds, and so on—so the household system is quite familiar to us.

For medical purposes, household measures are not as accurate as apothecaries' or metric measures. So why use them at all? The reason is that medicine orders sometimes have to be translated into terms that patients can understand and use on their own. Particularly in home care, patients need to be able to take medicines in doses that can be measured with utensils they have on hand (teaspoons, tablespoons, medicine droppers, etc.).

The basic units of the household system are listed in Table 4-5. All household

Table 4-4 The metric system

WEIGHT	VOLUME
microgram (μg, mcg)	milliliter (ml)
milligram (mg, Mgm)	cubic centimeter (cc, cm^3)
gram (g, Gm)	kilogram (kg)
liter (L, ℓ)	

EQUIVALENTS

One milliliter is the same as 1 cubic centimeter, and both weigh 1 gram

1000 milliliters = 1 liter = 1000 cubic centimeters

1000 micrograms = 1 milligram

1000 milligrams = 1 gram

1000 grams = 1 kilogram

100 milligrams = 0.1 gram

10 milligrams = 0.01 gram, etc.

SIMPLE CONVERSIONS

From grams to milligrams:

g × 1000 = mg

Hint: Move decimal point three places to the *right*

0.25 g = 250 mg

From milligrams to grams:

mg ÷ 1000 g

Hint: Move decimal point three places to the *left*

500 mg = 500 g = 0.5 g

dosages are written out in Arabic numerals.

DRUGS THAT ARE HARD TO MEASURE

Certain antibiotics and hormones from animal sources are impossible to weigh and measure in ordinary ways. Their strength is judged by the quantity shown to cause certain effects in laboratory animals and human volunteers—the bioassay technique you studied in Unit 1. Rather than being dispensed in grams or grains, these drugs are dispensed in solutions labeled with a certain number of **units** (U) per cubic centimeter or milliliter. Examples of these drugs are penicillin and insulin.

Table 4-5 The household system

WEIGHT (DRY)	VOLUME (LIQUID)
ounce (oz)	drop (gt); drops (gtt)
pound (lb)	teaspoon (t, tsp)
ton	tablespoon (T, tbsp)
	teacup (6 oz)
	cup (c) or glass (8 oz)
	pint (pt)
	quart (qt)
	gallon (gal)

EQUIVALENTS

16 ounces = 1 pound

3 teaspoons = 1 tablespoon = ½ ounce

16 tablespoons = 1 cup = 8 fluid ounces

2 cups = 1 pint

2 pints = 1 quart

4 quarts = 1 gallon

Converting between measurement systems

From time to time you will find it necessary to change, or convert, from one system of measurement to another. A physician will order medicine in grains, but the hospital pharmacy may send up the medication in grams. Or perhaps an order written for milliliters will have to be converted into teaspoons for a patient who will be taking the medicine at home. These types of conversions are usually performed by the pharmacist or the nurse in charge. But other health workers should also know how to make simple conversions by referring to a conversion table. Table 4-6 shows the equivalents between measures in the apothecaries', metric, and household systems. As you can see, the equivalents are not exact, but approximate. A 10% error usually occurs in making conversions.

You can make most of the conversions you need if you know these four basic equivalents:

$0.1 \text{ mg} = \frac{1}{600} \text{ gr}$

$1 \text{ mg} = \frac{1}{60} \text{ gr}$

$60 \text{ mg} = 1 \text{ gr}$

$1 \text{ g} = 15 \text{ gr}$

Table 4-6 Commonly used measurement system equivalents[a]

APOTHECARIES'	METRIC	HOUSEHOLD
Liquid volume		
1 minim (♏) or m)	0.06 ml (or cc)	1 drop
15 minims	1 ml	15 drops (gtt)[b]
1 fluidram (fʒ)	4–5 ml	1 teaspoon (60 gtt)
4 fluidrams	15 ml	1 tablespoon
1 fluidounce (f℥)	30 ml	2 tablespoons (1 oz)
	180 ml	1 teacup (6 oz)
	240 ml	1 cup or glass (8 oz)
	500 ml	1 pint (16 oz)
	750 ml	1.5 pints (24 oz)
	1000 ml (1 L)	1 quart (32 oz)
Dry weight		
$\frac{1}{60}$ gr	1 mg	
1 gr	60 mg	
7½ gr	500 mg (0.5 g)	
15 gr	1000 mg (1 g)	
60 gr (1 dram)	4 g	
1 oz	30 g	1 oz
	500 g	1.1 lb
	1000 g (1 kg)	2.2 lb

[a] *Equivalents are approximate.*
[b] *This figure varies. The number of drops per milliliter depends on the substance being measured.*

If you can remember these, it is easy to work out other equivalents. Table 4-7 shows how this can be done. Study the table carefully, and note the simple formulas for converting between systems. You may use this table to make conversions needed in the dosage calculation exercises at the end of this unit. However, if you memorize the four basic equivalents shown above, you may be able to make the conversions in your head. For example, if you know that 1 gr is equivalent to about 60 mg, then logically 5 gr is about 300 mg and ¼ gr is about 15 mg.

A close look at Figure 4-3 should also be helpful. It shows the relative sizes of containers you might use to measure out doses in the various systems.

Table 4-7 Simple conversions between the metric and apothecaries' systems

MILLIGRAMS ⟷ GRAINS	GRAMS ⟷ GRAINS
0.1 mg = $\frac{1}{600}$ gr	1 g = 15 gr
0.2 mg = $\frac{2}{600}$ gr = $\frac{1}{300}$ gr	0.1 g = $\frac{15}{10}$ gr = $1\frac{1}{2}$ gr
0.3 mg = $\frac{3}{600}$ gr = $\frac{1}{200}$ gr	0.25 g = $\frac{15}{4}$ gr = $3\frac{3}{4}$ gr
0.4 mg = $\frac{4}{600}$ gr = $\frac{1}{150}$ gr	0.5 g = $\frac{15}{2}$ gr = $7\frac{1}{2}$ gr
0.5 mg = $\frac{5}{600}$ gr = $\frac{1}{120}$ gr	
0.6 mg = $\frac{6}{600}$ gr = $\frac{1}{100}$ gr	0.75 g = $\frac{3 \times 15}{4}$ gr = $11\frac{1}{4}$ gr
	2 g = 30 gr
1 mg = $\frac{1}{60}$ gr	5 g = 75 gr
2 mg = $\frac{2}{60}$ gr = $\frac{1}{30}$ gr	*Hint:*
3 mg = $\frac{3}{60}$ gr = $\frac{1}{20}$ gr	gr × 60 = mg
5 mg = $\frac{5}{60}$ gr = $\frac{1}{12}$ gr	mg ÷ 60 = gr
10 mg = $\frac{10}{60}$ gr = $\frac{1}{6}$ gr	g × 15 = gr
15 mg = $\frac{15}{60}$ gr = $\frac{1}{4}$ gr	gr ÷ 15 = g
20 mg = $\frac{20}{60}$ gr = $\frac{1}{3}$ gr	
30 mg = $\frac{30}{60}$ gr = $\frac{1}{2}$ gr	
60 mg = 1 gr	
120 mg = 2 gr	
180 mg = 3 gr	
240 mg = 4 gr	
300 mg = 5 gr	
600 mg = 10 gr	

Dosage calculation

The job of calculating dosages is much easier today than in the past. Now in some health facilities pharmacists do all of the calculating. They prepare drugs in unit packages that contain the correct amount of a drug for a single dose. In your facility, however, you may have to make simple dosage calculations as part of your daily routine. You will need to know how to do this correctly and confidently. In medication administration there is no room for error!

In this section, you will learn two simple procedures that can be used to calculate almost any type of dosage problem. The only math you need to know is how to multiply and divide using whole numbers and fractions. Use paper and pencil to do your calculations, and check them over carefully for errors. Some of the calculations are easy to do in your head. But practice with paper and pencil until you have mastered the techniques presented.

A brief review of fractions is provided in this unit beginning on page 77. To refresh your memory, turn to that review now, before reading the next section. If your arithmetic skills are weak, you will need some extra practice. There are many books available in the library or bookstore to help you brush up on your basic skills. Some of these are listed among the references at the back of this book.

CALCULATING NUMBER OF TABLETS OR CAPSULES

A type of calculation you will probably run into often is the following:

PROBLEM 1 The doctor orders 200 mg of a drug to be given 3 times a day. The pharmacy sends up a bottle of 50-mg capsules. You have to decide how many capsules to give for each dose.

A simple formula can be used to help you figure this out. The formula is:

Desired dose (what you WANT) ÷ Available dose per tablet or capsule (what you HAVE) = Number of tablets or capsules

or

$$\frac{\text{WANT}}{\text{HAVE}} = \text{Number of tablets or capsules}$$

What this formula does is help you set up a fraction that you can simplify using the rules for fractions (see Math Review). Applying the formula to Problem 1, you get:

Dose ordered (WANT): 200 mg
Available packaging (HAVE): 50-mg caps

$$\frac{\text{WANT}}{\text{HAVE}} = \frac{200\text{ mg}}{50\text{ mg}} = \frac{\overset{4}{\cancel{200}}\text{ mg}}{\underset{1}{\cancel{50}}\text{ mg}} = 4 \text{ capsules}$$

The correct dose, then, would be four capsules 3 times a day.

PROBLEM 2 The doctor orders 350 mg to be given once a day. All you have on

hand are 100-mg tablets. How many tablets should you give?

$$\frac{\text{WANT}}{\text{HAVE}} = \frac{350\text{ mg}}{100\text{ mg}} = \frac{\overset{3.5}{\cancel{350}\ \cancel{\text{mg}}}}{\underset{1}{\cancel{100}\ \cancel{\text{mg}}}} = 3\tfrac{1}{2}\text{ tablets}$$

Note that your answer included a fraction of a tablet. You may administer a half or a quarter of a tablet if the tablet is *scored* so that it breaks easily. If it is anything other than a scored tablet, ask the nurse in charge what to do. Dividing an unscored tablet is risky, and of course you should not attempt to divide capsules or specially coated tablets.

PROBLEM 3 Now try a problem involving another unit of measurement. You are to give 20 gr of aspirin to an arthritis patient. The aspirin tablets you have are 5 gr each. How many tablets do you give?

$$\frac{\text{WANT}}{\text{HAVE}} = \frac{\overset{4}{\cancel{20}\ \cancel{\text{gr}}}}{\underset{1}{\cancel{5}\ \cancel{\text{gr}}}} = 4\text{ tablets}$$

Note that both WANT and HAVE must be in the same unit of measurement (e.g., both milligrams or grains, etc.). This formula does *not* apply to a problem like:

$$\frac{100\text{ mg}}{5\text{ gr}}$$

PROBLEM 4 What if the dosage ordered is a fractional dosage? For example, let's say the doctor orders ½ gr and your tablets are ¼ gr. Setting up the WANT/HAVE formula, you get:

$$\frac{\tfrac{1}{2}\text{ gr}}{\tfrac{1}{4}\text{ gr}} \longleftarrow \text{(Remember, this line means "divided by")}$$

To work this out, use what you know about dividing fractions. You invert the bottom fraction and turn it into a multiplication problem.

$$\frac{1}{2} \div \frac{1}{4} = \frac{1}{\underset{1}{\cancel{2}}} \times \frac{\overset{2}{\cancel{4}}}{1} = 2\text{ tablets}$$

INFORMATION SHEET
#100-001-001
"MEASUREMENT AND DOSAGE CALCULATION"
(continued)

PROBLEM 5 The same procedure can be applied to situations where drugs are mixed into solutions. For example, the label on a bottle of elixir says it contains 5 gr of medication per teaspoon. The doctor has ordered 15 gr of medication.

$$\frac{\text{WANT}}{\text{HAVE}} = \frac{15\ \text{g}}{5\ \text{gr/tsp}} = 3\ \text{tsp}$$

PROBLEM 6 It also works for units of penicillin mixed in sterile water for injection. A vial states that it contains 100,000 units of penicillin per cubic centimeter. You are to inject 300,000 units.

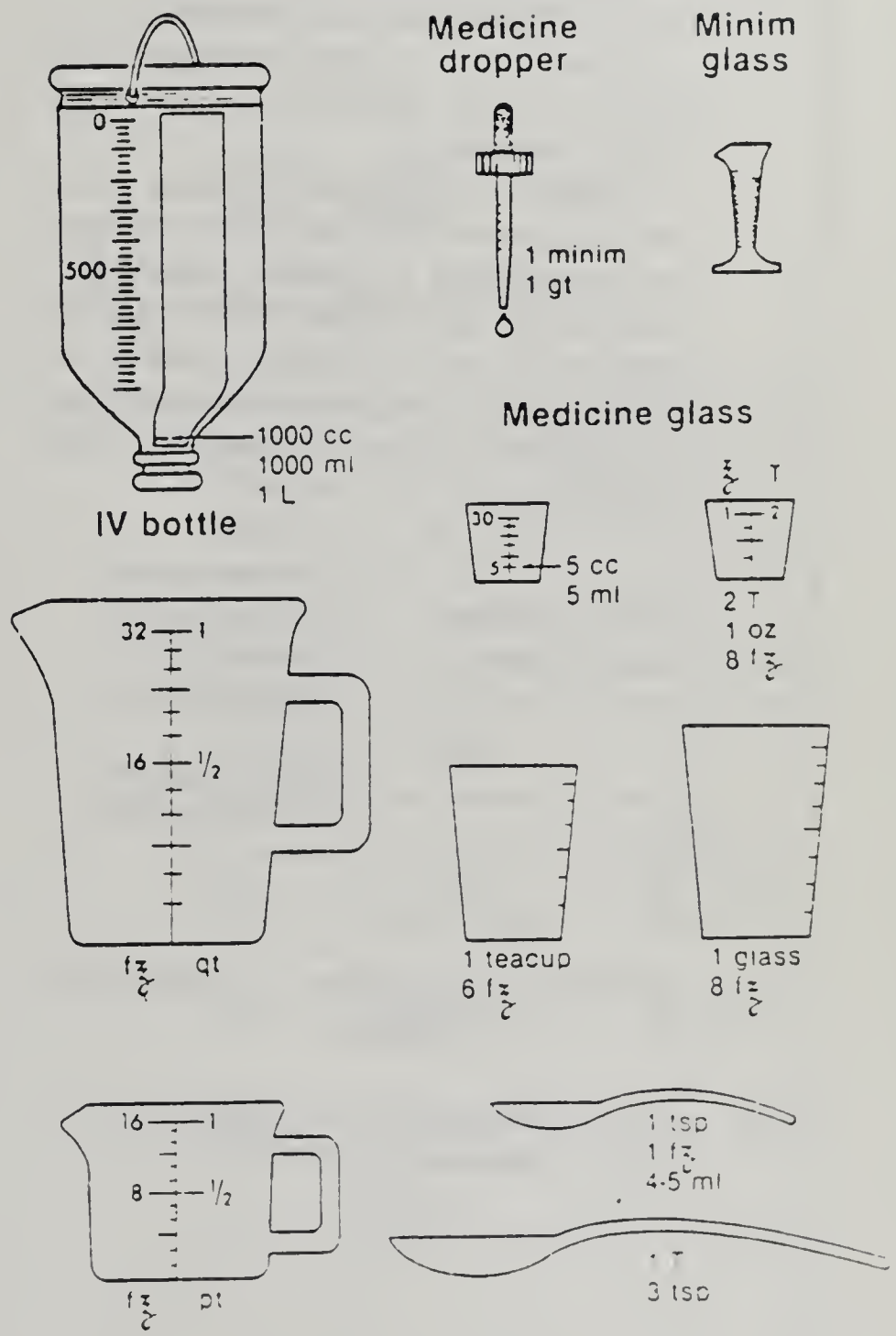


Fig. 4-3 Relative sizes of measuring containers.

$$\frac{\text{WANT}}{\text{HAVE}} = \frac{300{,}000 \text{ units}}{100{,}000 \text{ units/cc}} = 3 \text{ cc}$$

DOSAGE CALCULATIONS WITH CONVERSIONS

Suppose that the doctor orders a dose in grams, but your capsules are labeled in milligrams. Perhaps the order is in grains and your tablets are labeled in milligrams. Or suppose that the order is in milliliters and you want to instruct the patient in how much to take at home using a teaspoon.

Dosage calculations in which you need to convert from one system or unit of measurement to another cannot be handled by the simple WANT/HAVE formula. A more complex formula is needed, but it is easy to use and can be adapted to a variety of situations. The formula is:

Dosage in ordered unit (KNOWN) × Conversion fraction (relation of UNKNOWN to KNOWN units) = Dose in desired unit (UNKNOWN)

or

KNOWN × conversion fraction = UNKNOWN

This formula is best explained in the context of some sample problems.

PROBLEM 7 The doctor orders 0.5 g of ampicillin to be given 4 times a day. You want to know how many milligrams one dose would be. Your problem is:

0.5 g = ? mg (KNOWN unit is 0.5 g; UNKNOWN unit is ? mg)

To solve the problem, set up a calculation that will allow you to cancel the gram unit and give you the answer in milligrams.

$$0.5 \text{ g} \times \frac{? \text{ mg}}{? \text{ g}} = \text{answer in milligrams}$$

You do this by means of a "conversion fraction." This fraction differs according to the particular problem. It is designed to show the equivalence between the known and unknown units of measurement. The known type of unit should be in the denominator. For this problem, the conversion fraction is $\frac{? \text{ mg}}{? \text{ g}}$. You must fill in the missing quantities.

First you set the quantity of either unit to 1. Then you find out how many of the other unit are contained in that quantity. In this case, let us set the quantity of grams at 1. One gram contains 1000 mg, so you fill in the fraction like this:

$$\frac{1000 \text{ mg}}{1 \text{ g}}$$

Note that this fraction is equal to 1, because the numerator and the denominator both represent the same quantity, only in different units. *Remember, the denominator must be in the same unit of measurement as the KNOWN dose.*

Now you can solve the problem by canceling the gram unit and multiplying:

$$0.5 \cancel{\text{g}} \times \frac{1000 \text{ mg}}{1 \cancel{\text{g}}} = 0.5 \times 1000 \text{ mg}$$

$$= 500 \text{ mg}$$

PROBLEM 8 Take another example, this one involving a conversion between household measures. You are to give a patient 6 tsp of milk of magnesia as necessary for constipation. How many tablespoons would that be? In other words, 6 tsp = ? T (KNOWN unit is 6 tsp, UNKNOWN is ?T).

Set up the calculation so that you can cancel out the teaspoons and get the answer in tablespoons:

$$6 \text{ tsp} \times \frac{?\text{ T}}{?\text{ tsp}} = \text{answer in tablespoons}$$

You know that 3 tsp = 1 T, so you can fill in the conversion fraction as $\frac{1\text{ T}}{3\text{ tsp}}$

Proceed to solve as follows:

$$\overset{2}{\cancel{6}}\ \cancel{\text{tsp}} \times \frac{1\text{ T}}{\underset{1}{\cancel{3}}\ \cancel{\text{tsp}}} = 2\text{ T}$$

PROBLEM 9 Next, try a problem that involves converting from one measurement system to another. The order is for Pro-Banthine gr ss, and you have tablets that are labeled in milligrams. Use the above procedure to find: ½ gr = ? mg.

$$\frac{1}{2}\text{ gr} \times \frac{?\text{ mg}}{?\text{ gr}} = \text{answer in mg}$$

From memory (or looking at Table 4-7), you know that 1 gr = 60 mg, so:

$$\frac{1}{\cancel{2}}\ \cancel{\text{gr}} \times \frac{\overset{30}{\cancel{60}}\text{ mg}}{1\ \cancel{\text{gr}}} = 30\text{ mg}$$

Now, suppose that your tablets of Pro-Banthine are 15 mg each. How many 15-mg tablets would it take to make 30 mg? Some quick mental figuring tells you that you should give the patient two tablets. If in doubt, you can use the WANT/HAVE formula, now that you have already converted from grains to milligrams.

$$\frac{\text{WANT}}{\text{HAVE}} = \frac{\overset{2}{\cancel{30}}\text{ mg}}{\underset{1}{\cancel{15}}\text{ mg}} = 2\text{ tablets}$$

CHILDREN'S DOSES

As you learned in Unit 2, children need smaller doses of medicine than adults. There are two ways to adjust dosages for children: by age and by weight. In both cases, you can use the basic KNOWN/UNKNOWN procedure you have just learned. But first, here is the way children and adults are defined for the purpose of calculating dosages.

	Age	*Weight*
Infant	0–24 months (up to 2 years)	Less than 150 lb
Child	24–150 months (2 to 12½ years)	Less than 150 lb
Adult	150 months and over (more than 12½ yrs)	Over 150 lb

ADJUSTING DOSES BY AGE A 6-month-old infant is to be given a dose of tetracycline. The usual adult dose is 250 mg. You should set up the problem like this:

$$\text{Patient's age (in months)} \times \frac{\text{Usual adult dose}}{\text{Adult age (in months)}} = \text{Child's dose}$$

The adult age is always 150 months (12½ years) in this way of calculating. After filling in the proper numbers for your problem, you would get (mo = months):

$$6\ \cancel{\text{mo}} \times \frac{250\ \text{mg}}{150\ \cancel{\text{mo}}} = \frac{1500\ \text{mg}}{150} = 10\ \text{mg}$$

The infant would therefore be given 10 mg of tetracycline.

Suppose that you were giving tetracycline to an 8-year-old. Eight years is the same as 96 months (8 × 12 = 96), so your problem would look like this:

$$96\ \cancel{\text{mo}} \times \frac{250\ \text{mg}}{150\ \cancel{\text{mo}}} = \frac{24000\ \text{mg}}{150} = 160\ \text{mg}$$

ADJUSTING DOSES BY WEIGHT You can figure out a child's dose by weight just as you did by age. An adult is considered to weigh 150 lb in this formula:

$$\text{Patient's weight} \times \frac{\text{Usual adult dose}}{\text{Adult weight (always 150 lb)}} = \text{Child's dose}$$

A doctor orders Dilantin for a 30-lb. child. The usual adult dose is 100 mg. Your calculation would look like this:

$$\overset{1}{\cancel{30}}\ \text{lb} \times \frac{100\ \text{mg}}{\underset{5}{\cancel{150}}\ \text{lb}} = \frac{100\ \text{mg}}{5} = 20\ \text{mg}$$

WHEN IN DOUBT

As a giver of medications, you share in the health care team's responsibility for making sure that the patient gets the correct dose. To meet this responsibility, you are learning all you can about dosage calculation and conversions between measurement systems. If you study hard and do the practice exercises until you have mastered them, you will be prepared to handle most routine dosage questions. However, you must also recognize your limitations. If you are the least bit confused about a conversion, or if you are unsure about a particular calculation, get some help. Ask the physician, the nurse in charge, or the pharmacist to check your work. There should be no shame in asking for assistance in this area. After all, the main concern is the welfare of the patient. What could be more important than getting the dose right?

ACTIVITY SHEET

#100-001-002

"REVIEW MEASUREMENT AND DOSAGE CALCULATIONS"

A. Select the BEST answer.

1. The range of quantities that can produce therapeutic effects of most drugs is

   A. dosage range.
   B. volume space.
   C. unit dosage.
   D. measurement.

2. The basic unit of weight in this system of measurement is the _____ and the basic unit of volume is the _____.

   A. minim, grain.
   B. grain, minim.
   C. weight, volume.
   D. liquid, dry.

3. The system of measurement described in question 2 is

   A. household.
   B. metric.
   C. dosage.
   D. apothecary.

4. A single formula used to calculate the number tablets or capsules is

   A. $\frac{\text{have}}{\text{want}}$

   B. $\frac{\text{known}}{\text{unknown}}$

   C. $\frac{\text{want}}{\text{have}}$

   D. $\frac{\text{age}}{\text{weight}}$

ACTIVITY SHEET

#100-001-002 (Cont.)

5. Children need smaller doses of medicine than adults. Two ways to adjust dosages for children is by

   A. $\frac{\text{known}}{\text{unknown}}$

   B. $\frac{\text{want}}{\text{have}}$

   C. $\frac{\text{age}}{\text{weight}}$

6. The more complex formula used to calculate dosages with conversions is

   A. $\frac{\text{known}}{\text{unknown}}$

   B. $\frac{\text{want}}{\text{have}}$

   C. $\frac{\text{age}}{\text{weight}}$

A. Matching.

Choose from Column B the correct answer and place on the space provided in Column A.

Column A	Column B
_____1. apothecary	A. basic unit of wt. in apothecary system
_____2. dram	B. system of measurement
_____3. grain	C. 1, 2, 3, 4 and so on.
_____4. liter	D. basic unit of volume in metric system
_____5. metric	E. 60 grains
_____6. milligram	F. one-thousandth of a gram
_____7. minim	G. basic unit of volume in apothecaries system
_____8. Roman	H. I, II, III, IV, and so forth

INTERMEDIATE OBJECTIVE #2

2. Measure and calculate dosage.

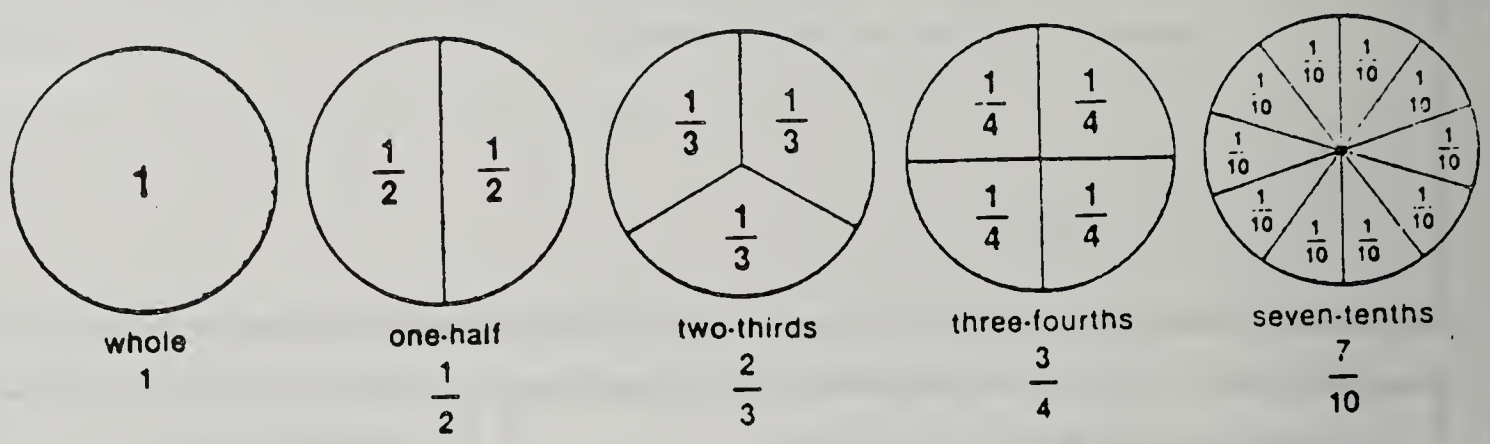
LEARNING STEPS (Activities)	RESOURCES
1. Cosult Resource #1 for a review on basic mathematics.	1. See instructor and Job sheet 100-002-001, pgs. 21 - 27, "Review Basic Math" in this S.L.G.
2. Upon mastery of this basic Math Review, see resource #2 for an introduction to measurement and dosage calculations.	2. See instructor
3. Complete Resource #3 for an exercise on measure and calculate dosage.	3. Job sheet 100-002-003, "Exercise on Measurement and Calculation of dosage," pgs.28-33 in this SLG. See instructor for evaluation.
4. For mastery of this task, complete Resource #4 for a performance evaluation.	4. Performance checklist, pgs. 34-35 in this SLG. See instructor for evaluation.
5. Complete resource #5 for a written evaluation.	5. Written Criterion Exam, Task #100 , "Measure and calculate dosage," in LRC. See instructor for evaluation.
6. Prodeed to Resource #6.	6. See instructor for next learning guide.

JOB SHEET

Math Review: Fractions

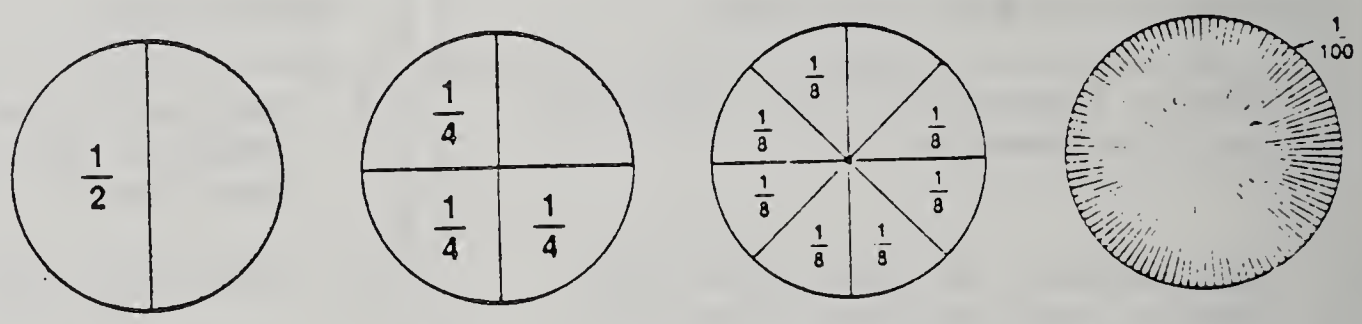
Definitions

A fraction is a way of expressing an *amount that is part of a whole:*

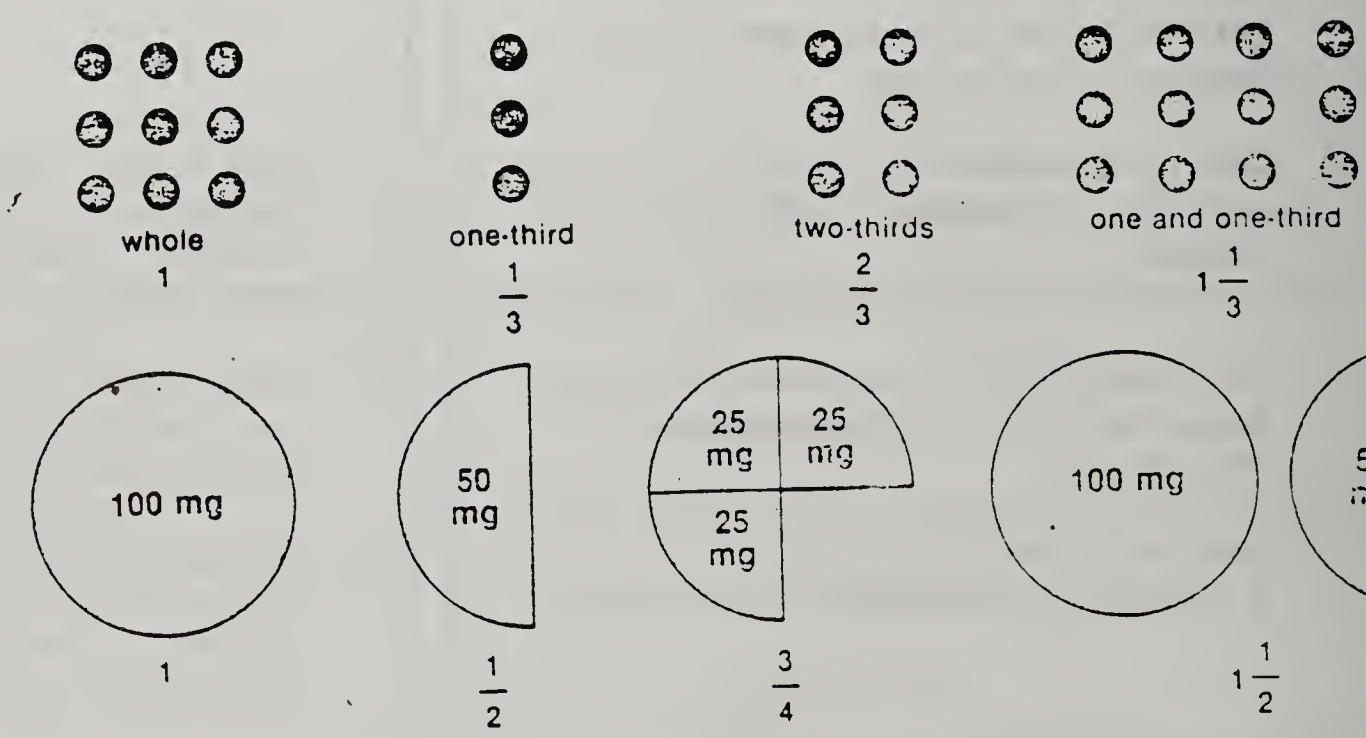


whole 1 | one-half $\frac{1}{2}$ | two-thirds $\frac{2}{3}$ | three-fourths $\frac{3}{4}$ | seven-tenths $\frac{7}{10}$

The more parts the whole is divided into, the smaller each part has to be:



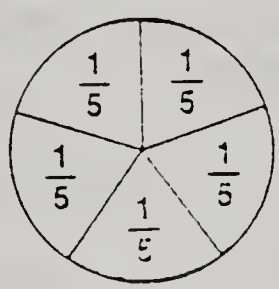
The whole can be a set of things, for example, nine dots or 100 mg:



whole 1 | one-third $\frac{1}{3}$ | two-thirds $\frac{2}{3}$ | one and one-third $1\frac{1}{3}$

1 | $\frac{1}{2}$ | $\frac{3}{4}$ | $1\frac{1}{2}$

A fractional amount of a whole is expressed like this:



$\frac{3}{5}$ ← NUMERATOR: how many parts of the whole you are taking

5 ← DENOMINATOR: how many equal parts the whole is divided into

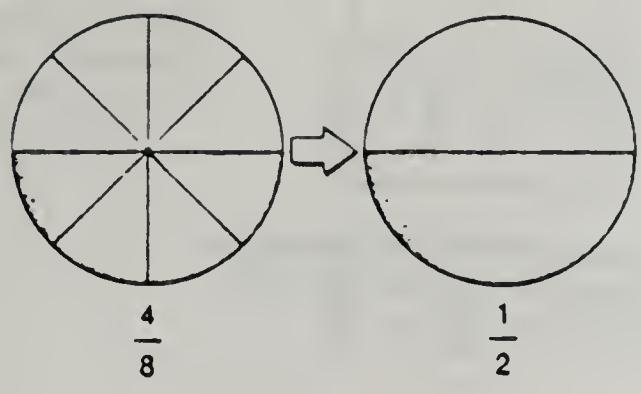
A fraction is also a way of expressing a *relationship between two numbers* or quantities; for example, $\frac{3}{4}$ means "3 divided by 4" which can also be expressed as:

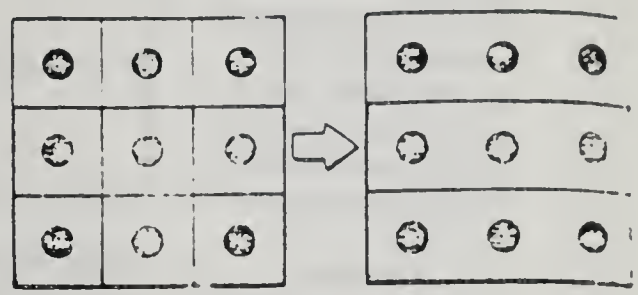
$3 \div 4$ *or* $4\overline{)3}$ *or* $3 : 4$ (ratio)

JOB SHEET
#100-002-001

Simplifying fractions

To make calculations easier, fractions may be *reduced to lowest terms:*





To reduce a fraction to lowest terms, *divide* both the numerator and the denominator by the largest number that will go into both of them evenly; for example:

$$\frac{4}{8} = \frac{4 \div 4}{8 \div 4} = \frac{1}{2}, \qquad \frac{6}{9} = \frac{6 \div 3}{9 \div 3} = \frac{2}{3}$$

When you reduce a fraction, the amount stays the same, but the fraction is easier to work with.

(Note: If there is no number that goes into both the numerator and denominator evenly, you cannot reduce the fraction: it is already in lowest terms.)

Canceling is a short-cut way of showing that you have divided the top and bottom of the fraction by the same number. Here is how it is shown in written work:

$\frac{3}{15}$ You wish to reduce $\frac{3}{15}$ to lowest terms, so you divide top and bottom by the largest number that will go into both of them evenly, or 3.

$\frac{\cancel{3}^{1}}{\cancel{15}_{5}}$ Three goes into 3 once, so you cancel out the 3 and write 1. Three goes into 15 five times, so you cancel out the 15 and write 5.

$\frac{1}{5}$ Thus, after reducing to lowest terms, the fraction is $\frac{1}{5}$.

Units of measurement can be canceled, too, as long as the same type of unit appears in both the numerator and the denominator:

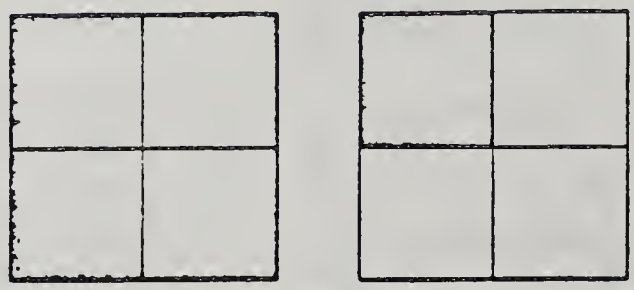
$$\frac{18\ \cancel{mg}}{25\ \cancel{mg}} \quad \textit{or} \quad \frac{3\ \cancel{gr}}{5\ \cancel{gr}} \quad \textit{but not} \quad \frac{3\ gr}{50\ mg}$$

A relationship like $\frac{350\ mg}{25\ mg}$ means the same as:

$$350\ mg \div 25\ mg \quad \textit{or} \quad 25\ mg\,\overline{)350\ mg} \quad \textit{or} \quad 350\ mg : 25\ mg$$

JOB SHEET
#100-002-001

To simplify a "top-heavy" fraction (or **improper fraction**) where the numerator is larger than the denominator, turn it into a **mixed number** (whole number and fraction) as follows:



$$\frac{5}{4} = 1\frac{1}{4} \qquad \left(4\overline{)\,5}\ \ \text{1 rem 1}\right)$$

Divide the numerator by the denominator. Express the remainder as a fraction with the same denominator.

Such top-heavy fractions are changed to mixed numbers *only* in giving the final answer to a problem. During calculations, mixed numbers are awkward to work with and must be changed to improper fractions.

Multiplying fractions

To multiply a fraction by another fraction, multiply *numerator* × *numerator* and *denominator* × *denominator* (× = *times*):

$$\frac{3}{10} \times \frac{1}{10} = \frac{3 \times 1}{10 \times 10} = \frac{3}{100}$$

$$\frac{5}{8} \times \frac{2}{3} = \frac{5 \times 2}{8 \times 3} = \frac{10}{24}$$

Remember to reduce the answer to lowest terms.

$$\frac{\overset{5}{\cancel{10}}}{\underset{12}{\cancel{24}}} = \frac{5}{12} \quad \text{(divided top and bottom by 2)}$$

To multiply a fraction by a whole number, multiply *whole number* × *numerator*.

$$\frac{7}{9} \times 2 = \frac{7}{9} \times \frac{2}{1} = \frac{14}{9} = 1\frac{5}{9}$$

(You may express the whole number as a fraction by giving it the denominator "1.") Then place the product over the denominator and simplify.

JOB SHEET

#100-002-001

In multiplying fractions, you are allowed to cancel *across* the times sign as follows:

$$\frac{3}{\cancel{4}_{1}} \times \frac{\cancel{4}^{1}}{5} = \frac{3 \times 1}{1 \times 5} = \frac{3}{5}$$

$$\frac{\cancel{8}^{4}}{9} \times \frac{5}{\cancel{14}_{7}} = \frac{4 \times 5}{9 \times 7} = \frac{20}{63}$$

You divide the denominator of one fraction and the numerator of the opposite fraction by the same number. This makes your job easier because you work with smaller numbers.

In the same way, you may cancel identical units of measurement across the times sign. This is important for certain formulas in dosage calculation:

$$2\ \cancel{\text{tsp}} \times \frac{5\ \text{ml}}{1\ \cancel{\text{tsp}}} = 10\ \text{ml}$$

$$\cancel{7.5\ \text{gr}}^{.5} \times \frac{1\ \text{g}}{\cancel{15\ \text{gr}}_{1}} = 0.5\ \text{g}$$

Dividing fractions

Flip over (invert) the divisor and then *multiply* the two fractions:

$$\frac{1}{2} \div \overset{\text{invert}}{\frac{2}{3}} = \frac{1}{2} \times \frac{3}{2} = \frac{3}{4}$$

$$\frac{5}{8} \div \frac{5}{9} = \frac{\cancel{5}^{1}}{8} \times \frac{9}{\cancel{5}_{1}} = \frac{9}{8}$$

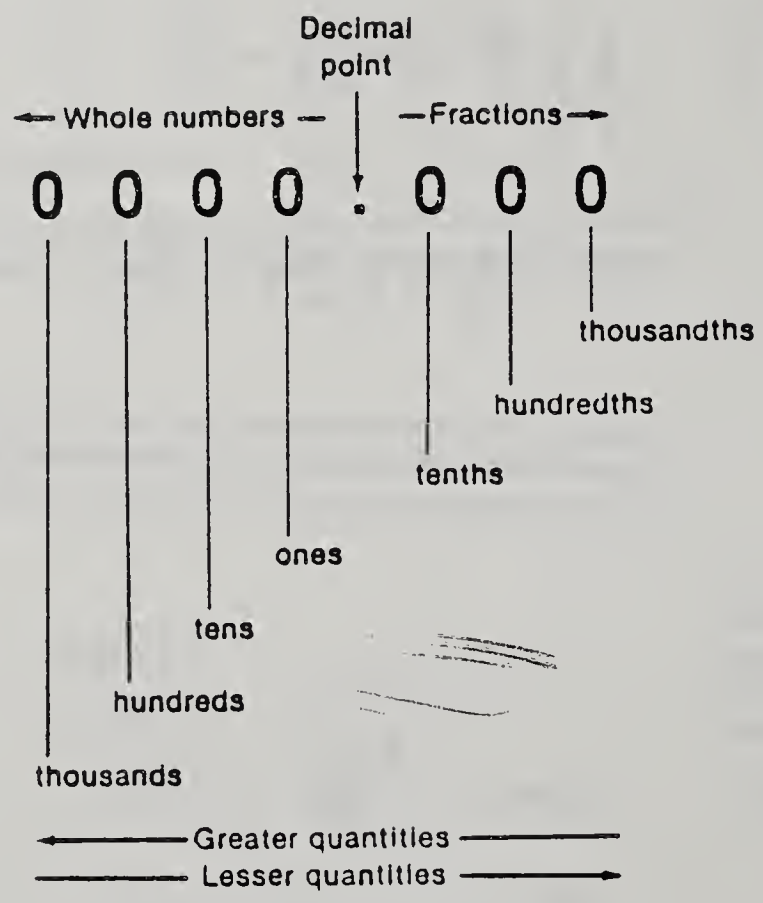
$$\frac{4}{5} \div 3 = \frac{4}{5} \times \frac{1}{3} = \frac{4}{15}$$

JOB SHEET
#100-002-001

Decimal fractions

In working with metric measures, fractions are expressed as decimals. Here is how the decimal system works:

The placement of numbers in relation to the decimal point tells their value. All the place values are multiples of ten.



Here are some examples of various whole numbers and fractions expressed as decimals:

$1.0 \rightarrow 1\frac{0}{10} \rightarrow 1$

$0.75 \rightarrow \frac{75}{100} \rightarrow \frac{3}{4}$

$0.66 \rightarrow \frac{66}{100} \rightarrow \frac{2}{3}$

$0.5 \rightarrow \frac{5}{10} \rightarrow \frac{1}{2}$

$0.33 \rightarrow \frac{33}{100} \rightarrow \frac{1}{3}$

$0.25 \rightarrow \frac{25}{100} \rightarrow \frac{1}{4}$

$0.125 \rightarrow \frac{125}{1000} \rightarrow \frac{1}{8}$

JOB SHEET

As you see above, any decimal fraction can be expressed as a regular or common fraction. Note the position of the final digit relative to the decimal point:

$$0.48 \rightarrow \frac{48}{100} \rightarrow \frac{\overset{12}{\cancel{48}}}{\underset{25}{\cancel{100}}} \rightarrow \frac{12}{25}$$

hundredths

$$1.6 \rightarrow 1\frac{6}{10} \rightarrow 1\frac{\overset{3}{\cancel{6}}}{\underset{5}{\cancel{10}}} \rightarrow 1\frac{3}{5}$$

tenths

Any common fraction can be changed to a decimal fraction by dividing the numerator by the denominator:

$$\frac{1}{3} \rightarrow \begin{array}{r} 0.333,\text{etc.} \\ 3\,\overline{)\,1.00} \\ 9 \\ \hline 10 \\ 9 \\ \hline 1 \end{array} \rightarrow 0.33$$

To multiply decimal fractions:

$$1.5 \times 0.35 = ?$$

Set up your multiplication like a normal multiplication problem:

$$\begin{array}{r} 1.5 \\ \times\, 0.35 \\ \hline 75 \\ 45 \\ \hline 0.525 \end{array}$$

To decide where the decimal point goes, look at the original problem and count the total number of places shown to the right of the decimal point, in this case 3.

$$\underbrace{1.5}_{1} \times \underbrace{0.35}_{2\ 3} = \underbrace{0.525}_{3\ 2\ 1}$$

Then, starting from the last digit of the answer, count that many places to the left and place the decimal right after that digit.

More examples:

$$100 \times \underbrace{0.01}_{1\,2} = \underbrace{1.00}_{2\,1}$$

$$\underbrace{3.25}_{1\,2} \times \underbrace{0.002}_{3\,4\,5} = \underbrace{0.00650}_{5\,4\,3\,2\,1}$$

$$\underbrace{2.5}_{1} \times \underbrace{1.4}_{2} = \underbrace{3.50}_{2\,1}$$

Placing the decimal point correctly is *very* important. A misplaced decimal means a huge error in dosage calculation.

Divide decimal fractions as follows:

$$30 \div 1.5 = ?$$

If there is a decimal fraction in the divisor, move it to the right past the rightmost digit, making the divisor a whole number. Count how many places you moved it. Then move the decimal in the dividend the same number of places to the right. The decimal should be placed directly above that point in the quotient (answer).

$$\begin{array}{r l} & \overline{2\,0.} \leftarrow \text{quotient} \\ \text{divisor} \leftarrow 1.5 & \overline{)\,30.0} \leftarrow \text{dividend} \end{array}$$

If there is no decimal fraction in the divisor, the quotient gets a decimal point directly above the one in the dividend:

$$\begin{array}{r l} & \overline{2.0} \\ 15 & \overline{)\,30.0} \end{array}$$

JOB SHEET #100-002-003

"EXERCISES ON MEASUREMENT AND CALCULATION OF DOSAGE"

Exercises

A. Write abbreviations for these units of measurement.

1. minim _____
2. grain _____
3. dram _____
4. fluidram _____
5. ounce _____
6. drops _____
7. pint _____
8. teaspoon _____
9. tablespoon _____
10. pound _____
11. milligram _____
12. milliliter _____
13. cubic centimeter _____
14. liter _____
15. gram _____

B. Practice decoding abbreviations. The following dosage orders are given using Roman numerals and abbreviations for the apothecaries system of measurement. Write them out in full, using arabic numerals.

1. ʒ iv _____
2. gr lss _____
3. fʒ vii _____
4. m ii _____
5. fʒ ix _____

JOB SHEET #100-002-003

C. Practice with measurement systems. Use Tables 4-4, 4-6, and 4-7 to find the equivalents. See how many you can memorize.

1. A grain weighs the same as _____ minim(s) of liquid.
2. One minim is the same as _____ drop(s).
3. One milliliter is approximately equal to _____ drop(s).
4. Fifteen grains is about _____ gram(s).
5. One grain is about _____ milligram(s).
6. One gram is equal to _____ milligrams.
7. One milliliter is the same as _____ cubic centimeter(s).
8. One teaspoon is about _____ milliliter(s).
9. One-half of a gram equals _____ milligram(s).
10. One glass (8 oz) contains about _____ milliliter(s).
11. One milligram is about _____ grain.
12. One-tenth of a milligram is about _____ grain.
13. One liter (1000 cc) is about _____ quart(s).

D. Reduce these fractions to lowest terms.

1. $\frac{4}{8}$ =
2. $\frac{3}{9}$ =
3. $\frac{50}{100}$ =
4. $\frac{24}{32}$ =
5. $\frac{21}{28}$ =
6. $\frac{250}{1000}$ =
7. $\frac{12}{18}$ =
8. $\frac{25}{45}$ =
9. $\frac{225}{500}$ =
10. $\frac{36}{48}$ =
11. $\frac{18}{36}$ =
12. $\frac{15}{60}$ =

E. Change these improper fractions to mixed numbers.

1. $\frac{8}{3}$ =
2. $\frac{5}{2}$ =
3. $\frac{17}{12}$ =
4. $\frac{55}{20}$ =
5. $\frac{18}{4}$ =
6. $\frac{68}{3}$ =
7. $\frac{350}{100}$ =
8. $\frac{27}{5}$ =
9. $\frac{60}{15}$ =
10. $\frac{83}{20}$ =
11. $\frac{45}{7}$ =
12. $\frac{600}{60}$ =

JOB SHEET #100-002-003

F. Multiply these fractions. Reduce the answers to lowest terms.

1. $\frac{3}{10} \times \frac{1}{10} =$

2. $\frac{5}{8} \times \frac{2}{3} =$

3. $2 \times \frac{5}{8} =$

4. $\frac{5}{4} \times \frac{7}{6} =$

5. $\frac{11}{12} \times 3 =$

6. $7 \times \frac{2}{5} =$

7. $\frac{3}{4} \times \frac{4}{5} =$

8. $\frac{8}{9} \times \frac{5}{14} =$

9. $\frac{4}{9} \times \frac{4}{5} =$

10. $250 \text{ mg} \times \frac{1 \text{ gr}}{60 \text{ mg}} =$

11. $3 \text{ gr} \times \frac{60 \text{ mg}}{1 \text{ gr}} =$

12. $45 \text{ gr} \times \frac{1 \text{ g}}{15 \text{ gr}} =$

G. Divide these fractions. Reduce the answers to lowest terms.

1. $\frac{1}{2} \div \frac{2}{3} =$

2. $\frac{5}{8} \div \frac{5}{9} =$

3. $\frac{1}{60} \div 3 =$

4. $\frac{1}{60} \div \frac{1}{2} =$

5. $\frac{1}{12} \div \frac{3}{24} =$

6. $2 \div \frac{4}{15} =$

7. $1 \div \frac{1}{600} =$

8. $\frac{1}{60} \div \frac{1}{12} =$

9. $\frac{2}{6} \div \frac{3}{12} =$

10. $\frac{3}{8} \div \frac{5}{8} =$

11. $\frac{\frac{2}{15}}{\frac{1}{60}}$

12. $\frac{\frac{3}{5}}{\frac{2}{3}}$

H. Write these as decimal fractions:

1. $\frac{1}{2} =$

2. $\frac{1}{3} =$

3. $\frac{1}{4} =$

4. $\frac{2}{3} =$

5. $\frac{3}{4} =$

6. $\frac{6}{10} =$

7. $\frac{2}{5} =$

8. $\frac{12}{100} =$

9. $\frac{25}{100} =$

10. $\frac{89}{100} =$

11. $\frac{23}{1000} =$

12. $\frac{225}{1000} =$

13. $1\frac{2}{10} =$

14. $3\frac{3}{4} =$

15. $5\frac{78}{1000} =$

JOB SHEET #100-002-003

I. Write these as common fractions and reduce to lowest terms.

1. 0.75 =
2. 0.2 =
3. 0.33 =
4. 1.5 =
5. 23.02 =
6. 5.66 =
7. 0.25 =
8. 0.005 =
9. 0.375 =

J. Practice with decimal fractions:

1. $1.5 \times 3 =$
2. $1.5 \times 0.3 =$
3. $1.5 \times 0.03 =$
4. $2.75 \times 0.1 =$
5. $7.5 \div 25 =$
6. $7.5 \div 2.5 =$
7. $7.5 \div 0.25 =$
8. $4 \div 0.4 =$
9. $\frac{1.2}{0.03} \div \frac{2}{3} =$
10. $2.25\text{ g} \times \frac{15\text{ gr}}{1\text{ g}} =$
11. $3.2\text{ L} \times \frac{1000\text{ cc}}{1\text{ L}} =$
12. $0.5\text{ ml} \times \frac{15\text{ m}\gamma}{1\text{ ml}} =$

K. Change from grams to milligrams:

1. 0.1 g = _____ mg
2. 2.5 g = _____ mg
3. 0.03 g = _____ mg
4. 0.125 g = _____ mg
5. 3.45 g = _____ mg

L. Change from milligrams to grams:

1. 325 mg = _____ g
2. 1200 mg = _____ g
3. 3000 mg = _____ g
4. 5 mg = _____ g
5. 75 mg = _____ g

M. Use Table 4-7 if necessary to convert these dosages. But first try to do them in your head.

1. 0.1 mg = _____ gr
2. 0.5 mg = _____ gr
3. _____ mg = $\frac{1}{60}$ gr
4. 4 mg = _____ gr
5. _____ mg = 1 gr
6. 150 mg = _____ gr
7. _____ mg = 5 gr
8. 1 g = _____ gr
9. _____ g = 7½ gr
10. 3 g = _____ gr

JOB SHEET #100-002-003

N. Use the WANT/HAVE formula to solve these dosage problems:

1. The doctor orders 250 mg of a drug. You have 100-mg scored tablets on hand. You will give the patient _____ tablets.
2. The medication order calls for a dose of 1¼ gr aspirin. Aspirin comes in scored tablets of 5 gr each. You will give the patient _____ tablet. (*Hint:* 1¼ = 5/4.)
3. The physician orders 75 mg of a drug. You have capsules of 25 mg each. You give the patient _____ capsules.
4. An injectable antibiotic is packaged 100,000 units/cc. The doctor orders 400,000 units. A certified nurse will administer _____ cc to the patient parenterally.
5. A solution contains 25 mg of a drug per teaspoon. The doctor ordered 50 mg. You give _____ tsp.
6. You have ½-gr tablets. You want to give ¼ gr. You administer _____ tablet(s).
7. The doctor's order says to give gr xv. The medicine bottle says each 5-ml teaspoon contains 7½ gr. You give _____ tsp. (*Hint:* 7½ gr = 15/2 gr.)

O. Use the KNOWN/UNKNOWN formula or Table 4–7 to solve these dosage problems involving conversions:

1. The doctor orders 600 mg. The dosage form on hand is gr x tablets. You give _____ tablet(s). (*Hint:* Find 600 mg = ? gr, then use the WANT/HAVE formula.)
2. You have ¼-gr tablets on hand, and the doctor has ordered 15 mg of the drug. You give _____ tablet(s).
3. The doctor ordered ¾ gr. The tablets on hand contain 30 mg each. You give _____ tablet(s). (*Hint:* Find ¾ gr = ? mg, then use the WANT/HAVE formula.)
4. An order is for 45 minims of a drug, but you do not have a measuring container marked in minims. You do have a container marked in milliliters. You administer _____ ml.

P. Practice with dosage calculations: translate each medication order and then answer the dosage questions:

1. An order reads: Hyoephen f℥i t.i.d. (p.o.) × 5 days.
   a. You do not have a glass container marked in fluidounces. What household measure could you use? _____
   b. How many tablespoons are there in f℥i (f℥i = ? T)? _____
   c. How many fluidounces do you need for a 1-day supply of Hyoephen? _____
   d. How many fluidounces of Hyoephen are needed in 5 days? _____
   e. How many pints do you order from the pharmacy to have a 5-day supply of Hyoephen (15 f℥ = ? pt)? _____
2. An order reads: Fer-in-Sol 18 mg q.d. p.c. One teaspoon supplies 18 mg of iron. The pharmacy sends up an 8-oz bottle of Fer-In-Sol.
   a. How many teaspoons are there in an 8-oz. bottle (8 oz = ? tsp)? _____
   b. About how many days will the bottle of Fer-In-Sol last? _____

Q. Practice calculating dosages for children. The usual adult dose of Dilantin is 100 mg.

1. How much Dilantin would you give to a child 9 months old? _____
2. How much Dilantin would you give to a child who weighs 34 lb? _____
3. How much would you give to a 10-year old? _____
4. How much would you give to a 16-year old? _____

R. Extra practice with conversions.

1. How many grams would you give if the order is 10 mg of Valium? _____
2. How many cubic centimeters do you give when the order is 2 L of Ringer's lactate? _____
3. How many tablespoons would you give if the order is 8 oz of Gelusil? _____
4. How many drops do you give when the order is ½ tsp? _____
5. How many milligrams of phenobarbital would you give if the order was for 2 gr? _____
6. You have capsules containing 0.5 g of a drug. The doctor ordered 500 mg. How many capsules do you give? _____

PERFORMANCE/PRODUCT CHECKLIST

Program: MEDICAL ASSISTING

Task No: 100

Student's Name: _____ Date Of Attempt: _____

Evaluator's Name: _____ Evaluation Site: _____

Performance Attempt: 1 2 3 4

Terminal Performance Objective:

Given the necessary tools and equipment, measure and calculate dosage.

Directions To The Student:

Before attempting this task for mastery, carefully review this checklist. You will be evaluated on the basis of this checklist. When you feel you are ready for evaluation, contact your instructor. You must complete your performance within 10 minutes and must score at least 4 out of 5 points or 90 % for mastery. Critical items are marked with an asterisk (*). These items must be satisfactorily completed.

Directions To The Evaluator:

The student will contact you when ready for the evaluation. The student must complete the performance within 10 minutes and must score 4 out of 5 points or 90 % and all items marked with an asterisk (*) must be satisfactorily completed.

CRITICAL ITEMS	ITLMS TO BE OBSERVED OR CHECKED	RATING	
		YES	NO
*	1. Solve the WANT/HAVE problem.		
*	2. Solve the KNOWN/UNKNOWN problem.		
*	3. Calculate the problem given on the dosage for a child.		
	4. Calculate the problem with a conversion		
*	5. Translate the medication order.		

TOTAL POINTS EARNED =

POINTS NEEDED FOR MASTERY = 4
TOTAL POINTS POSSIBLE = 5

PROGRAM Medical Assisting

CRITERION EXAM

TASK # 100

DIRECTIONS:

THE PURPOSE OF THIS EXAM IS TO DETERMINE WHETHER OR NOT YOU HAVE UNDERSTOOD THE INFORMATION ON ~~Measuring and Calculating Dosage~~

Each of the questions or incomplete statements below is followed by several words, phrases, or a series of numbers. Choose the one which best answers the question or completes the statement correctly. Place the letter associated with that choice (A,B,C or D) in the numbered blank space on your ANSWER SHEET. DO NOT WRITE ON THIS TEST!!! To master this exam you must answer 9 out of 10 items correctly, 90 %.

EVALUATION SHEET

WRITTEN CRITERION EXAM Task #100
"MEASURE AND CALCULATE DOSAGE"

Select The Best Answer.

1. A_____ is the basic unit of weight in the apothecary system measurement.

   A. Grain
   B.
   C. Gram
   D. Dram

2. Feet, inches, miles, pints, quarts prounds and so on are measurements of the _____system.

   A. Apothecary
   B. Household
   C. Metric
   D. Pharmaceutical

3. One grain is evuivalent to _____ milligrams (____ mg.)

   A. 1/600
   B. 1/60
   C. 1
   D. 60

4. Fifteen grains (15 gr) is equivalent to _____ gram (_____ g).

   A. 0.1
   B. 0.01
   C. 0.15
   D. 1

5. If you know that 1 gr is equivalent to about 60 mg, then logically 5 gr is about 300 mg. and 1/4 gr is about _____ mg.

   A. 5
   B. 10
   C. 15
   D. 60

6. The doctor orders 350 mg to be given once a day. All you have on hand are 100mg tablets. How many tablets should you give? (Show steps in solving problem).

   A. 3 tablets
   B. 3 and 1/2 tablets
   C. 4 tablets
   D. 4 and 1/2 tablets

EVALUATION SHEET

7. You are to give a patient 6 tsp. of milk of magnesia as necessary for constipation. How many tablespoons would that be? (Show steps in solving problem).

   A. 1 T.
   B. 2 T.
   C. 3 T.
   D. 4 T.

8. Suppose that you were giving tetracyclive to an 8 year old child. Eight years is the same as 96 months (8 X 12= 96) (Show Calculations).

   A. 16 mg.
   B. 160 mg.
   C. 600 mg.
   D. 1600 mg.

9. A doctor orders dilantin for a 30 lb. child. The usual adult dose is 100 mg. (Show calculations).

   A. 2 mg.
   B. 20 mg.
   C. 200 mg.
   D. 1200 mg.

10. Convert simply 0.25 to milligrams.

   A. 25 mg.
   B. 250 mg.
   C. 0.5 mg.
   D. 1000 mg.

LAKE
COUNTY
AREA
VOCATIONAL
CENTER

COMPETENCY-BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

STUDENT LEARNING GUIDE

Produced By ROSEMARIE MEYER, RN, CMA Date 11/84

TASK: PERFORM RETICULOCYTE COUNT

PURPOSE:

The reticulocyte count is an important diagnostic tool. It is a relatively accurate reflection of the amount of effective red cell production taking place in the bone marrow. This learning guide will assist you to perform a reticulocyte count.

MEDICAL ASSISTING

Program	Task	Est.Time	Prereq.
07.0904	128	10 hrs	

edk

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME _____ SOCIAL SECURITY NUMBER _____

LENGTH OF CONTRACT (NORMAL TIME IN HOURS) 10 hrs

2. TERMINAL PERFORMANCE OBJECTIVE

Given the necessary reagents and equipment, perform a reticulocyte count. To master this task you must score 17 out of 18 (90%) on a performance evaluation and 9 out of 10 (90%) on a written criterion examination.

2a. INTERMEDIATE OBJECTIVE(s)

1. Describe reticulocyte count.
2. Perform reticulocyte count.

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____. I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

Student's Signature _____

Instructor's Signature (verifies competency) _____

Program	Task	Page
07.0904	128	1

INTERMEDIATE OBJECTIVE #1

Describe reticulocyte count.

LEARNING STEPS (Activities)

1. Read Resource #1 for information on reticulocyte count.

2. Complete Resource #2 for a review on reticulocyte count.

3. Proceed to Resource #3.

RESOURCES

1. Information Sheet 128-001-001, "Reticulocyte Count," pages in this SLG. * Information taken from textbook: Hematology: Principles and Procedure, by Barbara Brown, 3rd edition, pages 95-100.

2. Job Sheet 128-001-002, "Review Reticulocyte Count," pages 9 - 11 in this SLG.

   See instructor for evaluation.

3. Intermediate Objective #2, page 12 in this SLG.

RETICULOCYTE COUNT

The red blood cell goes through six stages of development: rubriblast, prorubricyte, rubricyte, metarubricyte, reticulocyte, and mature red blood cell. The first four stages are normally confined to the bone marrow. The reticulocyte, however, is found in both the bone marrow and peripheral blood. In the bone marrow, it spends approximately 2 days maturing and is then released to the blood, where it matures for another day, prior to becoming a mature red blood cell.

The reticulocyte count is an important diagnostic tool. It is a relatively accurate reflection of the amount of effective red cell production taking place in the bone marrow. Since the life span of a red blood cell is 120 days, ±20 days, the bone marrow replaces approximately 1% of the adult red blood cells every day. The normal values for a reticulocyte count are, therefore, 0.5% to 1.5%. The reticulocyte count is expressed as the number of reticulocytes present, per 100 red blood cells (in %). A decreased reticulocyte count is found in aplastic anemia and in conditions in which the bone marrow is not producing red blood cells. Increased reticulocyte counts are found in hemolytic anemias, iron deficiency anemias receiving iron therapy, thalassemia, sideroblastic anemia, and acute and chronic blood loss.

Corrected Reticulocyte Count. An accurate reticulocyte count should reflect the total production of red cells regardless of the concentration of red cells in the blood (red blood count). As an example, compare the following two patients. Patient No. 1 has a hematocrit of 42% and a reticulocyte count of 1.0%. Patient No. 2 has a hematocrit of 21% and a reticulocyte count of 2.0%. Patient No. 2, theoretically, has half as many red cells as patient No. 1 but has the same number of reticulocytes as patient No. 1 because the reticulocytes are diluted by only half the number of red cells, as in patient No. 1. To compensate for this, a corrected reticulocyte count is calculated, based on a normal hematocrit of 42% for women and 45% for men. The formula for this correction follows.

$$\text{Corrected reticulocyte count in \%} = \frac{\text{Patient's hematocrit}}{\text{Normal hematocrit}} \times \text{Reticulocyte count in \%}$$

In addition to correcting a reticulocyte count for an abnormally low hematocrit, consideration is also given to the presence of marrow reticulocytes present in the peripheral blood. In this circumstance, the reticulocyte production index is calculated. As previously stated, the reticulocytes spend approximately 2 days in the bone marrow before being released into the blood. In certain situations, these marrow reticulocytes are released directly into the blood, prior to maturation in the marrow. This is detected by nucleated red blood cells and/or polychromatophilic macrocytes ("shift" cells) present in the circulating blood. To correct for this reticulocyte maturation delay, the reticulocyte production index is calculated by dividing the corrected reticulocyte count by two. In patients showing no nucleated red cells or "shift" cells, the corrected reticulocyte count is divided by one (normal reticulocyte maturation time) and the reticulocyte production index is equal to the corrected reticulocyte count.

In conditions of anemia, the bone marrow normally shows a response to this anemia by increasing red cell production. At the same time, the reticulocyte count in the blood also is increased. See Table 3 for the normal bone marrow response to a decreased hematocrit.

TABLE 3. NORMAL BONE MARROW RESPONSE TO ANEMIA

HEMATOCRIT	RETICULOCYTE COUNT	CORRECTED RETICULOCYTE COUNT
45	1.0%	1.0%
35	6.5%	2–3%
25	14.0%	3–5%
15	24.0%	3–5%

REAGENTS AND EQUIPMENT

1. Reticulocyte stain. Any of the following staining solutions may be employed:
   A. New methylene blue N solution

Sodium chloride	0.8 g
Potassium oxalate	1.4 g
New methylene blue N	0.5 g
Distilled water	100 ml

   B. Brilliant cresyl blue solution

Brilliant cresyl blue	1.0 g
Sodium chloride, 0.85% (w/v)	99 ml

   Filter both of the preceding staining solutions prior to use.
2. Glass slides.
3. Applicator sticks or microhematocrit tubes.
4. Microscope.

SPECIMEN

Whole blood (1 ml), using EDTA, heparin, or ammonium-potassium oxalate as the anticoagulant. Capillary blood from the finger, toe, or heel may also be used.

PRINCIPLE

After the metarubricyte loses its nucleus, a small amount of RNA remains in the red cell, and the cell is known as a reticulocyte. To detect the presence of this RNA, the red cells must be stained while they are still living. This process is called *supravital staining*. After the cells have been stained by either new methylene blue N or brilliant cresyl blue, the number of reticulocytes in 1,000 red cells is determined. This number is divided by ten in order to obtain the reticulocyte count in percent.

PROCEDURE

1. Place three drops of filtered reticulocyte stain in a small test tube.
2. Add three drops of blood to the test tube containing the stain. (Ensure that the blood specimen is well mixed.)
3. Mix the tube contents and allow to stand for a minimum of 15 minutes, or incubate specimen at 37°C for 15 minutes. This allows the reticulocytes adequate time to take up the stain.
4. At the end of 15 minutes, mix the contents of the tube well.
5. Using applicator sticks, or a microhematocrit tube, place a drop of the mixture on each of three slides and make smears.
6. Stain with Wright's stain, using the same method as previously described for routine blood smears. (This step is not necessary and may be omitted. See step No. 9, below, for explanation.)
7. Allow smears to air-dry.
8. Place the first slide on the microscope stage and, using the low power objective (10 ×), find an area in the thin portion of the smear in which the red cells are evenly distributed and are not touching each other. Carefully change to the oil immersion objective (100 ×) and further locate an area in which there are approximately 100 to 200 red cells per oil immersion field.
9. As soon as the proper area is selected, the reticulocytes may be counted. If the smear has not been counterstained with Wright's stain, the red cells are a light to medium green in color. The RNA present in the reticulocytes stains a deep blue. When counterstaining with Wright's stain, the red cells are pink, whereas the RNA in the reticulocytes stains a deep purple. The reticulum may be abundant or sparse, depending upon the cell's stage of development. The youngest reticulocyte shows a larger amount of RNA (Fig. 112), whereas the more mature reticulocyte shows only a small amount of RNA (Fig. 112C). Count all of the red blood cells in the first field on one cell counter. At the same time enumerate the

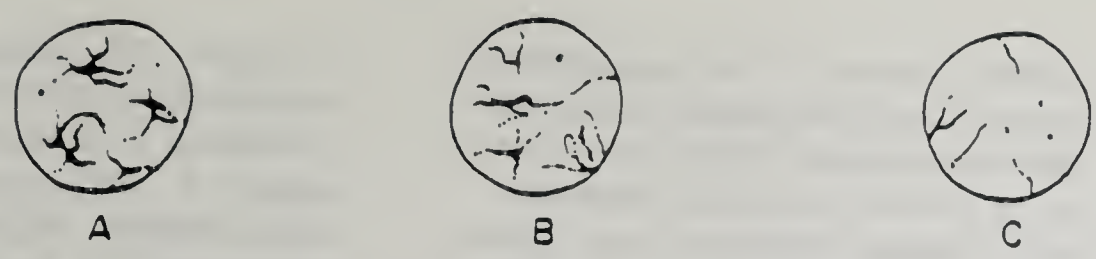


FIG. 112. Stages of maturation in the reticulocyte.

reticulocytes (Fig. 113) in the same field with a second cell counter. Move the slide as described for the differential count until all reticulocytes in 1000 red cells have been counted.

10. A second technologist should repeat the reticulocyte count in the same manner as described in step 9 on the second reticulocyte smear. The two results should agree within ±10% of each other. If they do not, repeat the reticulocyte count on the third smear.
11. Average the two results and calculate the reticulocyte count as shown below.

$$\% \text{ Reticulocytes} = \frac{\text{Number of reticulocytes counted in 1000 red cells}}{10}$$

12. Calculate the corrected reticulocyte count. If marrow reticulocytes or nucleated red blood cells are present, also calculate the reticulocyte production index.

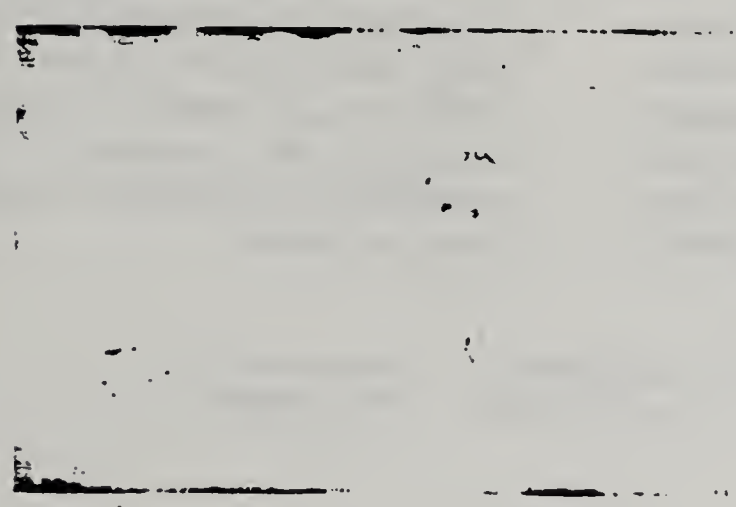


FIG. 113. Reticulocytes. (Supravital staining of the red blood cells with new methylene blue N.) (Magnification × 1000.)

DISCUSSION

1. There are various methods in use for mixing the stain and blood for a reticulocyte count: (1) A microhematocrit tube is a third filled with blood, to which is added an equal amount of stain. This mixture is rotated back and forth in the hematocrit tube, allowed to stand for 15 minutes, remixed, placed on slides, and smears made. (2) Blood is drawn up to the 1.0 mark in the white cell pipet. Wipe off the outside of the pipet and, in order to have a space at the tip of the pipet, allow the blood to run up a short distance into the pipet bulb. Draw stain up to the 1.0 mark. Remove the tip of the pipet from the bottle of stain and draw the stain up into the bulb of the pipet to mix with the blood. (The bulb of the pipet is not full, but contains an equal volume each of blood and stain.) Mix the contents of the pipet, allow to stand for 15 minutes, remix, and make smears.
2. The blood-to-stain ratio does not have to be exactly equal. For best results, a larger proportion of blood should be added to the stain when the patient's hematocrit is low. Add a smaller amount of blood to the stain when the patient has an unusually high hematocrit.
3. The time allowed for staining of the reticulocytes is not critical. It should, however, never be less than 10 minutes.
4. It is extremely important that the blood and stain be mixed well prior to

making smears. The reticulocytes have a lower specific gravity than mature red cells and therefore settle on top of the red cells in the mixture.

5. Each clinical laboratory may show slight alterations in the reticulocyte method, but all are based on the same general principles as described here. Also, corrections for the hematocrit are not carried out in all laboratories.
6. Red cells are frequently noted on the reticulocyte smear that contain areas that are highly refractile. These cells should not be confused with reticulocytes. This condition is probably due to moisture in the air and poor drying of the smear.
7. The presence of high concentrations of glucose in the blood causes the reticulocytes to be poorly stained.
8. New methylene blue N is preferred to brilliant cresyl blue as a reticulocyte stain due to the inconsistent staining properties of the latter.
9. The range of error in the reticulocyte count varies, depending on the number of reticulocytes counted. Using the previously outlined procedure, there is an error of approximately ±25% in the reticulocyte counts within the normal range. This decreases to ±10% in a reticulocyte count of 5%, and decreases even further as the uncorrected reticulocyte count increases.
10. There are several methods of counting reticulocytes once the smears have been made: (1) One procedure utilizes the Miller disc that is placed inside the microscope eyepiece. This disc consists of two squares as shown in Figure 115. The area of the smaller square (B) is a tenth that of square A. Therefore, if there are 40 red cells in square A, there should be four red cells present in square B. When employing this method to count reticulocytes, the red cells in square B are counted in successive fields on the slide, until a total of 500 red cells have been counted. At the same time, the reticulocytes in square A are enumerated. At the completion of the count, theoretically, the reticulocytes contained in 5000 red cells have been counted. The number of reticulocytes obtained in this way is divided by 50, in order to obtain the percent reticulocytes present in the blood. The count is also performed in duplicate, using a second smear, and the results averaged to obtain the test value. This method is somewhat time-consuming. (2) Place a small "window" in the eyepiece of the microscope. This makes the field smaller and the counting of cells easier. (Cut out a round piece of paper the same diameter as the eyepiece and cut a square hole in the center. Unscrew the top lens of the eyepiece, insert the paper, and replace the top lens.) (3) For reticulocyte counts less than 10%, count at least 100 reticulocytes (except in extremely low counts where this would not be practical). Instead of counting the number of red cells in every field, count the red cells in every 8 to 10 fields and also keep track of the number of fields examined. Calculate the reticulocyte count as follows:

$$\frac{\text{Total number of RBCs counted}}{\text{Number of fields in which RBCs were counted}} \times \text{Total number of fields examined} = \text{Total number of RBCs examined}$$

$$\%\ \text{Reticulocytes} = \frac{\text{Number of reticulocytes counted}}{\text{Total number of RBCs examined}} \times 100$$

FIG. 114. Heinz bodies. (Supravital staining of red blood cells with new methylene blue N. Compare with reticulocytes stained similarly.) (Magnification × 1000.)

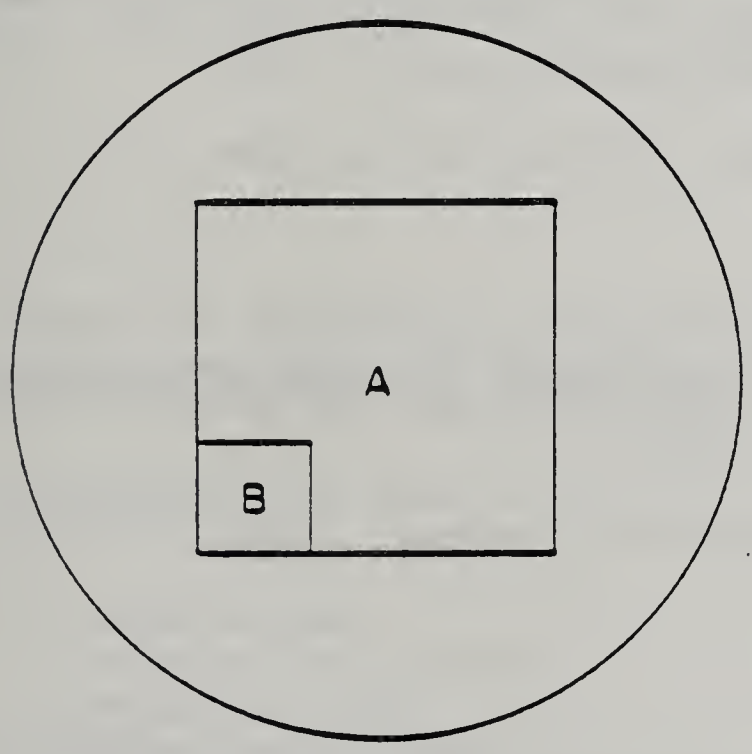


FIG. 115. Miller disc.

11. There are several red cell inclusions that are stained by the new methylene blue N and brilliant cresyl blue stains, in addition to the RNA of the reticulocytes. Howell-Jolly bodies appear as one, sometimes two, round, deep-purple-staining structures. Heinz bodies stain a light blue-green and are usually present at the peripheral edge of the red cell (Fig. 114). Pappenheimer bodies are most often confused with reticulocytes and are the most difficult to distinguish from reticulocytes. These purple-staining iron deposits generally appear as several granules in a small cluster. If Pappenheimer bodies are suspected, a Wright-stained smear may be examined to verify their presence.

JOB SHEET

128-001-002

"Review Reticulocyte Count"

1. The first four stages of development of RBC, the rubriblase, prorubricyte, rubricyte, and metarubricyte are normally continued to

   A. peripheral blood.
   B. bone marrow.
   C. capillary blood.
   D. cell morphology.

2. The _____ is found in both the bone marrow and peripheral blood.

   A. white blood cell
   B. reticulocyte
   C. erythrocyte
   D. mature RBC

3. The bone marrow replaces 1% of the adult red blood cells every day. The normal values for a reticulocyte count, therefore,

   A. 0.15% - 0.5%.
   B. 0.5% - 1.0%.
   C. 0.5% - 1.5%.
   D. 1.5% - .50%.

4. The reticulocyte count is expressed as the number of reticulocytes present, per _____ RBS's (in %).

   A. 10
   B. 50
   C. 100
   D. 1000

5. A decreased reticulocyte count is found in conditions in which the bone marrow is not producing red blood cells and

   A. aplastic anemia.
   B. pernicious anemia.
   C. iron-deficiency anemia.
   D. hemolytic anemia.

6. To correct for a reticulocyte naturation delay, the reticulocyte production index is calculated by dividing the corrected reticulocyte count by

   A. one.
   B. two.
   C. ten.
   D. fifty.

7. _____ cells are indicative of increased red cell production and appear somewhat larger than normal circulating red cells and are polychromatophilic.

   A. Macrocytes
   B. Microcytes
   C. Hematopoietic
   D. "Shift"

8. Compare the following patients.

   Pt. 1 HCT 42% Reticulocyte count 1.0%

   Pt. 2 HCT 21% Reticulocyte count 2.0%

   Patient #2, theoretically, has half as many red cells as patient #1, but has has the same number of reticulocytes as patient #1 because the reticulocytes are diluted by only half the number of red cells, as in patient #1.

   To compensate for this, a _____ _____ count is calculated, based on a normal hematocrit of 42% for woemn and 45% for men.

   A. complete blood
   B. corrected reticulocyte
   C. production index
   D. marrow reticulocyte

9. EDTA, Heparin, or ammonium-potassium oxalate are

   A. anticoagulants.
   B. red blood cells.
   C. staining solutions.
   D. reagents.

10. After the reticulocytes are stained, the number of reticulocytes in 1,000 red cells is divided by _____ in order to obrain the reticulocyte count in percent.

    A. one
    B. two
    C. five
    D. ten

11. The time allowed for staining of the reticulocytes is not critical, however, it should never be less than _____ minutes.

    A. one
    B. two
    C. five
    D. ten

12. The blood and stain is t be well mixed prior to making smears. Reticulocytes have a _____ specific gravity than mature red cells and therefore settle _____ of the red cells in the mixture.

    A. low, top
    B. high, bottom
    C. low, bottom
    D. high, top

13. High concentrations of _____ in the blood causes the reticulocytes to be poorly stained.

    A. water
    B. crystals
    C. glucose
    D. red cells

14. Howell-jolly bodies appear as deep-purple-staining stuctures and Heinz bodies stain a light _____ and are usually present at the peripheral edge of the red cell.

    A. bluish-purple
    B. reddish-pink
    C. blue-green
    D. purplish-blue

INTERMEDIATE OBJECTIVE #2

Perform reticulocyte count.

LEARNING STEPS (Activities)	RESOURCES
1. Observe Resource #1 for a demonstration on reticulocyte count.	1. See instructor.
2. Complete Resource #2 for a practice on performing reticulocyte count.	2. Job Sheet 128-002-002, "Practice Reticulocyte Count", page 13 in this SLG.
3. When mastery of this task has been accomplished, complete Resource #3 for a final performance.	3. Performance Checklist Task #128, "Perform Reticulocyte Count", page in this SLG. See instructor for evaluation.
4. Complete Resource #4 for a written evaluation.	4. Written Criterion Examination, Task #128, "Perform Reticulocyte Count" in LRC. See instructor forevaluation.
5. Proceed to Resource #5 for the next learning guide.	5. See instructor.

JOB SHEET
128-002-002
"Practive Reticulocyte Count"

Directions to the student:

Given the necessary reagents and equipment, practice performing reticulocyte count.

Necessary reagents and equipment:

1. Reticulocyte stain

(Filter prior to use)
a) New methylene blue in solution or
b) Brilliant cresyl blue solution

2. Glass slides.

3. Applicator sticks or microhematocrit tubes.

4. Microscope

Specimen 8

Whole blood (1 ml), using EDTA, heparin or ammonium-potassium oxalate as the anticoagulant. Capillary blood from the finger, toe, or heel may also be used.

Procedure: Page 97 - 98 textbook or refer to Procedures Manual in lab.

PERFORMANCE/PRODUCT CHECKLIST

Program: MEDICAL ASSISTING

Task No: 128

Student's Name: _____ Date Of Attempt: _____

Evaluator's Name: _____ Evaluation Site: _____

Performance Attempt: 1 2 3 4

Terminal Performance Objective:

Given the necessary reagents and equipment, perform a reticulocyte count.

Directions To The Student:

Before attempting this task for mastery, carefully review this checklist. You will be evaluated on the basis of this checklist. When you feel you are ready for evaluation, contact your instructor. You must complete your performance within 10 minutes and must score at least 17 out of 18 points or 90 % for mastery. Critical items are marked with an asterisk (*). These items must be satisfactorily completed.

Directions To The Evaluator:

The student will contact you when ready for the evaluation. The student must complete the performance within 10 minutes and must score 17 out of 18 points or 90 % and all items marked with an asterisk (*) must be satisfactorily completed.

CRITICAL ITEMS	ITLMS TO BE OBSERVED OR CHECKED	RATING YES	RATING NO
*	1. Wash hands		
*	2. Place $\frac{111}{111}$ gtts. of filtered reticulocyte stain in test tube		
*	3. Add $\frac{111}{111}$ gtts. of blood to the test tubes containing the stain		
*	4. Mix the tube contents and allow to stand for a minimum of 15 minutes		
*	5. Mix contents of tube well		
*	6. Use applicator sticks or a microhematocrit tube to place a drop of mixture on each of three slides		
*	7. Make smears		
*	8. Stain with Wright's stain as learned in routine blood smears		
*	9. Allow smears to air dry		
*	10. Place 1st slide on the microscope stage, using low power to find an area in this portion of the smear		
*	11. Change to oil immersion and locate an area of approximately 100 - 200 red cells per field		
*	12. Count reticulocytes in first field		
*	13. Enumerate the reticulocytes in same field with second cell counter		
*	14. Move slide as for a differential count until all reticulocytes in 1000 red cells have been counted		
*	15. Repeat the reticulocyte count with a second technologist - results should be within $\pm$ 10% of each other		
*	16. Average the two results		
*	17. Calculate the corrected reticulocyte count		
	18. Clean up working area		
	TOTAL POINTS EARNED =		

POINTS NEEDED FOR MASTERY = 17
TOTAL POINTS POSSIBLE = 18

PROGRAM MEDICAL ASSISTING

CRITERION EXAM

TASK = 128

DIRECTIONS:

THE PURPOSE OF THIS EXAM IS TO DETERMINE WHETHER OR NOT YOU HAVE UNDERSTOOD THE INFORMATION ON PERFORMING RETICULOCYTE COUNT.

Each of the questions or incomplete statements below is followed by several words, phrases, or a series of numbers. Choose the one which best answers the question or completes the statement correctly. Place the letter associated with that choice (A,B,C or D) in the numbered blank space on your ANSWER SHEET. DO NOT WRITE ON THIS TEST!!! To master this exam you must answer 9 out of 10 items correctly, 90%.

EVALUATION SHEET

Written Criterion Examination
TASK #128
"Perform Reticulocyte Count"

Select the BEST answer:

1. The _____ is found in both the bone marrow and peripheral blood

   A. shite blood cell
   B. reticulocyte
   C. erythrocyte
   D. maturea RBC

2. The bone marrow replaces 1% of the adult red blood cells every day. The normal values for a reticulocyte count, therefore,

   A. 0.15% - 0.5%
   B. 0.5% - 1.0%
   C. 0.5% - 1.5%
   D. 1.5% - .50%

3. The reticulocyte count is expressed as the number of reticulocytes present, per _____ RBC's (in %).

   A. 10
   B. 50
   C. 100
   D. 1000

4. A decreased reticulocyte count is found in conditions in which the bone marrow is not producing red blood cells and

   A. aplastic anemis.
   B. pernicious anemia,
   C. iron deficiency anemia.
   D. hemolytic anemia.

5. _____ cells are indicative of increased red cell production and appear somewhat larger than normal circulating red cells and are polychromatophilic.

   A. Macrocytes
   B. Microcytes
   C. Hematopoietic
   D. "Shift"

EVALUATION SHEET

Written Criterion Examination
TASK #128
"Perform Reticulocyte Count"

6. After the reticulocytes are stained, the number of reticulocytes in 1,000 red cells is divided bt _____ in order to obtain the reticulocyte count in percent.

   A. one
   B. two
   C. five
   D. ten

7. The time allowed for staining fo the reticulocytes is not critical, however, it should never be less than _____minutes.

   A. one
   B. two
   C. five
   D. ten

8. The blood and stain is to be well mixed prior to making smears. Reticulocytes have a _____specific gravity than mature red cells and therefore settle on _____of the red cells in the mixture.

   A. low, top
   B. high, bottom
   C. low, bottom
   D. high, top

9. High concentrations of _____ in the blood causes the reticulocytes in to be poorly stained.

   A. water
   B. crystals
   C. glucose
   D. red cells

10. Howell-jolly bodies appear as deep-purple-staining structures and Heinz bodies stain a light_____and are usually present at the peripheral edge of the red cell.

   A. bluish-purple
   B. reddish-pink
   C. blue-green
   D. purplish-blue

Program	Task	Page

LAKE COUNTY AREA VOCATIONAL CENTER

COMPETENCY-BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

Tech Deck

STUDENT LEARNING GUIDE

Produced By Rosemarie Meyer, RN, CMA Date 3/85

TASK: PERFORM BLEEDING AND CAPILLARY COAGULATION TIMES
* (HIGH TECH)

PURPOSE: THE BLOOD COAGULATION MECHANISM IS COMPLICATED AND INVOLVES MANY FACTORS. KNOWING WHICH FACTOR IS NOT PERFORMING ITS PROPER FUNCTION IS OF CRITICAL IMPORTANCE TO THE PHYSICIAN. THIS KNOWLEDGE IS GAINED THROUGH THE USE OF SEVERAL DIFFERENT LABORATORY TESTS. THIS LEARNING GUIDE WILL ASSIST YOU TO PERFORM BLOOD COAGULATION TESTS.

MEDICAL ASSISTING

emf

Program	Task	Est.Time	Prereq.
07.0904	530	10 H	

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME _____ SOCIAL SECURITY NUMBER _____

LENGTH OF CONTRACT (NORMAL TIME IN HOURS) 10 H

2. TERMINAL PERFORMANCE OBJECTIVE

Given the necessary tools and equipment, you will perform bleeding and capillary coagulation tests. To master this task you must score 4 (6) out of 5 (7), (90%) on a performance checklist and 14 out of 15 (90%) on a written criterion examination.

2a. INTERMEDIATE OBJECTIVE(s)

1. Describe bleeding and capillary coagulation times.
2. Perform bleeding and capillary coagulation times.

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____. I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

Student's Signature _____ Instructor's Signature (verifies competency) _____

INTERMEDIATE OBJECTIVE #1

DESCRIBE BLEEDING AND CAPILLARY COAGULATION TIMES.

LEARNING STEPS (Activities)

1. Read Resource #1 for information on bleeding and coagulation tests.

2. Complete Resource #2 for a review on bleeding and coagulation.

3. Proceed to Resource #3.

RESOURCES

1. Textbook: Basic Techniques for the Medical Laboratory by Linne and Ringsrud, pgs. 271 - 278, 2nd edition in LRC.

2. Job Sheet 530-001-002, "Review Bleeding and Coagulation," pg. 4-6 , in this SLG.

   See instructor for evaluation.

3. IO #2, pg. 7 , in this SLG.

JOB SHEET

530-001-002

"REVIEW BLEEDING AND COAGULATION"

SELECT THE BEST ANSWER.

1. The mechanism of coagulation takes place in three major steps: 1) The formation of thromboplastin, 2) the formation of thrombin, and 3) the formation of:

   A. fibrinogen.
   B. fibrin.
   C. prothrombin.
   D. coagulant.

2. In severe _____ disease a moderate lowering of the plasma fibrinogen level may occur, although rarely to the degree where hemorrhage occurs.

   A. liver
   B. spleen
   C. gallbladder
   D. pancreas

3. _____ is synthesized by the liver through the action of Vitamin K and converted to thrombin by the enzymatic action of thromboplastins.

   A. Fibrinogen
   B. Prothrombin
   C. Calcium
   D. Fibrin

4. _____ thromboplastin is used to designate thromboplastic reagents that are found to clot hemophilic plasma less rapidly than normal plasma whereas _____ thromboplastin is able to produce clotting as rapidly with hemophilic plasma as with normal plasma.

   A. Complete, partial
   B. Partial, complete
   C. Synthesized, manufactured
   D. Converted, produced

5. Clot-accelerating activity of injured tissues has the name factor _____.

   A. II
   B. III
   C. IV
   D. V

6. Factor I, _____, is the soluble precursor of the clot-forming protein, fibrin.

   A. fibrinogen
   B. prothrombin
   C. thromboplastin
   D. calcium

7. A sex-linked hereditary coagulation disorder is _____.

   A. anemia
   B. hemorrhage
   C. congenital
   D. hemophilia

8. The _____ mechanism is the interaction of platelets ⟶ thromboplastin ⟶ prothrombin ⟶ thrombin ⟶ fibrinogen ⟶ fibrin.

   A. bleeding
   B. coagulation
   C. agglutination
   D. hemostatic

9. _____ is the cessation of blood flow from an injured blood vessel.

   A. Hemostasis
   B. Coagulation
   C. Vasoconstriction
   D. Agglutination

10. _____ tests measure the time required for cessation of bleeding after a stab wound to a capillary bed.

    A. Clotting
    B. Prothrombin
    C. Agglutination
    D. Bleeding

11. The two most commonly used bleeding time tests are the _____ and _____.

    A. Duke, Ivy
    B. Quick, cuff
    C. PTT, Pro-time
    D. Lee-White, Mielke

12. The _____ test is the single most useful procedure available for routine screening of coagulation disorders.

    A. Pro-times
    B. Lee-White
    C. PTT
    D. Quick's

13. _____ specimens are always run along with the patient's specimen to ensure accurate results.

    A. Control
    B. Collected
    C. Mixed
    D. Refrigerated

14. The _____ test for Whole Blood Clotting is still used to monitor heparin therapy.

    A. PTT
    B. Lee-White
    C. Pro-time
    D. Titer

15. Excessive probing in venipuncture causes tissue juices to be introduced into the specimen (contamination of tissue thromboplastin). This _____ clotting time.

    A. alters
    B. lengthens
    C. shortens
    D. changes

INTERMEDIATE OBJECTIVE #2

PERFORM BLEEDING AND CAPILLARY COAGULATION TESTS.

LEARNING STEPS (Activities)

1. Observe Resource #2 for a demonstration on bleeding and coagulation tests.
2. Complete Resource #2 for practice on this task.
3. When you feel you have mastered this task, complete Resource #3.
4. Complete Resource #4 for a written evaluation.
5. Proceed to Resource #5.

RESOURCES

1. See instructor.
2. Job Sheet 530-002-001, "Perform Bleeding and Coagulation Tests," pg.8-9, in this SLG.
3. Performance Checklist, pg. 11, in this SLG.

   See instructor for evaluation.
4. Written Criterion Exam, "Perform Bleeding and Capillary Coagulation Tests," in the LRC.
5. See instructor for the next learning guide.

JOB SHEET

530-002-001

"PERFORM BLEEDING AND CAPILLARY COAGULATION TIMES"

BLEEDING TIME
(DUKE METHOD)

To do this exercise, you should work in pairs.
Prin.- Bleeding time is the time elapsed between the puncture of the finger and the cessation of bleeding.

PURPOSE:

1. To learn and develop proper techniques of doing bleeding time.

2. To note the time required for a small cut to stop bleeding.

MATERIALS:

1. Piece of filter paper

2. Watch with a second hand

3. Materials for finger puncture:
   a. Gauze pads
   b. Alcohol sponge
   c. Sterile blood lancets

PROCEDURE:

1. Thoroughly cleanse the ball of the patient's middle finger with alcohol sponge and dry it off.

2. Using a sterile blood lancet, make a finger puncture deep enough to insure free flow and quickly record the time.

3. Fold the filter paper in half and at exactly ½ minute after puncturing, lightly touch the filter paper to the blood coming out of the puncture.

4. Repeat the above step every ½ minute until blood ceases to flow

5. Record the time at which blood ceases.

Bleeding time normal - 1 to 3 minutes

JOB SHEET

530-002-001 (Cont'd)

COAGULATION TIME

CAPILLARY METHOD

To do this exercise, it is best to work in pairs.

Prin. - Coagulation time is the time required for blood to clot or coagulate.

PURPOSE:

1. To learn and develop proper technique of doing coagulation time

2. To note the time required for blood to clot or coagulate.

MATERIALS:

1. Watch with a second hand or a stop watch

2. Two plain capillary tubes

3. Materials for finger puncture:
   a. alcohol sponge
   b. gauze
   c. sterile blood lancet

PROCEDURE:

1. Thoroughly cleanse the ball of the middle finger with alcohol sponge and dry it off

2. With a sterile blood lancet, make a quick deep puncture on the ball of the patient's meddle finger.

3. Wipe off the first drop of blood and firmly massage the finger to produce a large rounded drop of blood and record time.

4. Put one end of the capillary tube in the drop of blood and tilt the other end of the capillary tube downward, allowing blood to flow into the capillary tube until it is full.

5. Wipe off the finger with a gauze and firmly massage the finger to get a large rounded drop of blood. Fill up a second capillary tube by repeating the drying, massaging and filling procedure.

6. Pick up the first capillary tube; using both hands break the capillary tube into 2 pieces being careful not to pull the broken ends too far apart.

7. Look for a thread-like span of fibrin between the 2 broken ends.

PERFORMANCE/PRODUCT CHECKLIST

Program: MEDICAL ASSISTING

Task No: 530

Student's Name: _____ Date Of Attempt: _____

Evaluator's Name: _____ Evaluation Site: _____

Performance Attempt: 1 2 3 4

Terminal Performance Objective:

Given the necessary tools and equipment, perform bleeding and capillary coagulation times.

Directions To The Student:

Before attempting this task for mastery, carefully review this checklist. You will be evaluated on the basis of this checklist. When you feel you are ready for evaluation, contact your instructor. You must complete your performance within 10 minutes and must score at least 4 (6) out of 5 (7) points or 90 % for mastery. Critical items are marked with an asterisk (*). These items must be satisfactorily completed.

Directions To The Evaluator:

The student will contact you when ready for the evaluation. The student must complete the performance within 10 minutes and must score 4 (6) out of 5 (7) points or 90 % and all items marked with an asterisk (*) must be satisfactorily completed.

CRITICAL ITEMS	ITLMS TO BE OBSERVED OR CHECKED	RATING YES	RATING NO
	BLEEDING TIME (DUKE METHOD)		
*	1. Thoroughly cleanse the ball of the patient's middle finger with alcohol sponge and dry it off.		
*	2. Using a sterile blood lancet, make a finger puncture deep enough to insure free flow and quickly record the time.		
*	3. Fold the filter paper in half and at exactly 1/2 minute after puncturing, lightly touch the filter paper to the blood coming out of the puncture.		
*	4. Repeat the above step every 1/2 minute until blood ceases to flow.		
*	5. Record the time at which blood ceases.		
	Bleeding time normal - 1 to 3 minutes.		
	COAGULATION TIME (CAPILLARY METHOD)		
*	1. Thoroughly cleanse the ball of the middle finger with alcohol sponge and dry it off.		
*	2. With a sterile blood lancet, make a quick deep puncture on the ball of the patient's middle finger.		
*	3. Wipe off the first drop of blood and firmly massage the finger to produce a large rounded drop of blood and record time.		
*	4. Put one end of the capillary tube in the drop of blood and tilt the other end of the capillary tube downward, allowing blood to flow into the capillary tube until it is full.		
*	5. Wipe off the finger with a gauze and firmly massage the finger to get a large rounded drop of blood. Fill up a second capillary tube by repeating the drying, massaging and filling process		
*	6. Pick up the first capillary tube; using both hands break the capillary tube into 2 pieces being careful not to pull the broken ends too far apart.		
*	7. Look for a thread-like span of fibrin between the 2 broken ends.		

TOTAL POINTS EARNED =

POINTS NEEDED FOR MASTERY = 4 (6)
TOTAL POINTS POSSIBLE = 5 (7)

PROGRAM MEDICAL ASSISTING

CRITERION EXAM

TASK = 530

DIRECTIONS:

THE PURPOSE OF THIS EXAM IS TO DETERMINE WHETHER OR NOT YOU HAVE UNDERSTOOD THE INFORMATION ON PERFORMING BLEEDING AND COAGULATION TESTS.

Each of the questions or incomplete statements below is followed by several words, phrases, or a series of numbers. Choose the one which best answers the question or completes the statement correctly. Place the letter associated with that choice (A,B,C or D) in the numbered blank space on your ANSWER SHEET. DO NOT WRITE ON THIS TEST!!! To master this exam you must answer 14 out of 15 items correctly, 90 %.

EVALUATION SHEET

530-002-004

SELECT THE BEST ANSWER.

1. _____ thromboplastin is used to designate thromboplastic reagents that are found to clot hemophilic plasma less rapidly than normal plasma whereas _____ thromboplastin is able to produce clotting as rapidly with hemophilic plasma as with normal plasma.

   A. Complete, partial
   B. Partial, complete
   C. Synthesized, manufactured
   D. Converted, produced

2. The mechanism of coagulation takes place in three major steps: 1) The formation of thromboplastin, 2) the formation of thrombin, and 3) the formation of:

   A. fibrinogen.
   B. fibrin.
   C. prothrombin.
   D. coagulant.

3. Excessive probing in venipuncture causes tissue juices to be introduced into the specimen (contamination of tissue thromboplastin). This _____ clotting time.

   A. alters
   B. lengthens
   C. shortens
   D. changes

4. The _____ test is the single most useful procedure available for routine screening of coagulation disorders.

   A. Pro-times
   B. Lee-White
   C. PTT
   D. Quick's

5. In severe _____ disease a moderate lowering of the plasma fibrinogen level may occur, although rarely to the degree where hemorrhage occurs.

   A. liver
   B. spleen
   C. gallbladder
   D. pancreas

6. The _____ mechanism is the interaction of platelets → thromboplastin → prothrombin → thrombin → fibrinogen → fibrin.

   A. bleeding
   B. coagulation
   C. agglutination
   D. hemostatic

7. The two most commonly used bleeding time tests are the _____ and _____.

   A. Duke, Ivy
   B. Quick, cuff
   C. PTT, Pro-time
   D. Lee-White, Mielke

8. Factor I, _____, is the soluble precursor of the clot-forming protein, fibrin.

   A. fibrinogen
   B. prothrombin
   C. thromboplastin
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9. _____ is synthesized by the liver through the action of Vitamin K and converted to thrombin by the enzymatic action of thromboplastins.

   A. Fibrinogen
   B. Prothrombin
   C. Calcium
   D. Fibrin

10. A sex-linked hereditary coagulation disorder is _____.

   A. anemia
   B. hemorrhage
   C. congenital
   D. hemophilia

11. Clot-accelerating activity of injured tissues has the name factor _____.

   A. II
   B. III
   C. IV
   D. V

EVALUATION SHEET

530-002-004 (Cont'd)

12. _____ is the cessation of blood flow from an injured blood vessel.

A. Hemostasis
B. Coagulation
C. Vasoconstriction
D. Agglutination

13. The _____ test for Whole Blood Clotting is still used to monitor heparin therapy.

A. PTT
B. Lee-White
C. Pro-time
D. Titer

14. _____ tests measure the time required for cessation of bleeding after a stab wound to a capillary bed.

A. Clotting
B. Prothrombin
C. Agglutination
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15. _____ specimens are always run along with the patient's specimen to ensure accurate results.

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B. Collected
C. Mixed
D. Refrigerated

LAKE
COUNTY
AREA
VOCATIONAL
CENTER

COMPETENCY-BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

STUDENT LEARNING GUIDE

Produced By Rosemarie Meyer R.N., C.M.A. Date 3/85

TASK: PREPARE SOLUTIONS

PURPOSE:

Preparation of solutions requires strict adherence to specific sets of instructions. Instructions provide the reader with the names of the chemical ingredients, the weights and volumes needed, and the total volume to which the reagent should be diluted. This learning guide will assist the student to prepare solutions.

MEDICAL ASSISTING

Program	Task	Est.Time	Prereq.
07.0904	555	10 hrs.	

edk

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME _____ SOCIAL SECURITY NUMBER _____

LENGTH OF CONTRACT (NORMAL TIME IN HOURS) 10 hrs.

2. TERMINAL PERFORMANCE OBJECTIVE

Given the necessary tools and equipment, prepare solutions. To master this task, you must score 7 out of 7 (100%) on a performance checklist and score 19 out of 20 (90%) on a written evaluation.

2a. INTERMEDIATE OBJECTIVE(s)

1. Describe solutions.
2. Prepare solutions.

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____. I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

Student's Signature _____

Instructor's Signature (verifies competency) _____

INTERMEDIATE OBJECTIVE #1

Describe solutions.

LEARNING STEPS (Activities)

1. Read Resource #1 for information on solutions.
2. Complete Resource #2 for a review on solutions.
3. Proceed to Resource #3.

RESOURCES

1. Information Sheet 555-001-001, "Solutions", pages 4 - 13, in this SLG.
2. Job Sheet 555-001-002, "Review Solutions", pages 14-17 in this SLG. See instructor or activity key for an evaluation.
3. Intermediate Objective #2, page 18 in this SLG.

TABLE 3-8 *Representative conversion factors for customary and metric measurements*[a]

TO CONVERT FROM	TO	MULTIPLY BY
Acres	Square feet	43,560
Acres	Square kilometers	0.004
Angstrom units	Centimeters	1×10^{-8}
Angstrom units	Nanometers	0.1
Centimeters	Feet	0.0328
Centimeters	Inches	0.3937
Feet	Inches	12
Feet	Meters	0.3048
Gallons (U.S. liquid)	Liters	3.7854
Gallons (U.S. liquid)	Ounces	128
Grams	Kilograms	0.001
Grams	Pounds	0.002
Inches	Meters	0.254
Inches	Yards	0.0278
Liters	Ounces	33.815
Liters	Pints	2.113
Meters	Feet	3.2808
Meters	Kilometers	0.001
Micrograms	Grams	1×10^{-6}
Micrometers	Angstrom units	10,000
Micrometers	Nanometers	1000
Pounds	Kilograms	0.45
Pounds	Grams	453.6
Square meters	Square feet	10.8
Square meters	Square yards	1.2
Yards	Meters	0.9
Yards	Centimeters	91.4

[a] Approximate.

appropriate factor to produce the unknown value in the needed unit. For example, suppose we wanted to determine the number of centimeters in 5 inches. The conversion factor is 2.54. Multiply 5 (inches) × 2.54 to produce 12.7 centimeters.

PREPARATION OF SOLUTIONS

Preparation of solutions requires strict adherence to specific sets of instructions. Instructions provide the reader with the names of the chemical ingredients, the weights or volumes needed, and the total volume to which the reagent should be diluted. Throughout this book we shall refer to the chemical ingredients as *reagents*. As you progress through *Medical Laboratory Skills*, reagent preparation will form an essential part of your training.

Read and follow the instructions for preparing reagents carefully. The quantities of chemicals listed in the order in which some chemicals are added, and the solvent used for dissolving or diluting are important considerations. Preparation of most solutions requires the use of volumetric glassware. This usually includes volumetric pipets and volumetric flasks or cylinders.

Many of the chemicals used in the laboratory are solids. These ingredients must be weighed in quantities of grams (g) or milligrams (mg). Liquids are usually measured by volume, in milliliters (ml), deciliters (dl), or liters (l). Only high-grade chemicals should be used as reagents and they should be obtained from a reputable supplier.

The Nature of Solutions

Solutions used as reagents in most clinical analyses consist of *solvents* and *solutes*. Solvents are substances, usually liquids, that dissolve a solid. Solutes are solids dissolved by solvents. Distilled or deionized water is most often used as a solvent. Tap water is *never* used in preparing reagents because of the impurities it may contain. Alcohols, acids, and combinations of liquids are sometimes used as solvents.

Some solutes dissolve as complete molecules and remain in that state. Other solutes, such as salts, break up into charged particles. These particles are called *ions*. When sodium chloride (NaCl) is dissolved in water it dissociates into charged particles. Sodium (Na^+) and chloride (Cl^-) ions are formed.

Solutes that ionize in solution are called *electrolytes*. Solutions of electrolytes can conduct electricity. The behavior of these solutions is different from solutions whose solutes remain in the molecular state.

Some of the solutions prepared for laboratory use are easily made by dissolving one or more solids in a liquid. Occasionally one or more liquids must be diluted with another liquid. More complicated solutions require heating, adjustment of pH, and additional steps such as refluxing or distillation.

Saturated solutions contain as much solute as can be held in solution. When a solution is saturated, excess amounts of solute will settle out of solution and remain on the bottom of the vessel.

Colloidal solutions are solutions in which the solute particles are atomic or molecular in size, but light enough to remain in suspension. Colloids cannot be filtered. Some substances are present in biological fluids

Taken from: Medical Laboratory Skills, by Wittman & Thomas

as colloidal suspensions. Reagents sometimes used in the laboratory are colloidal solutions.

Types of Solutions

The solutions used in most laboratory procedures do not require the writing of chemical equations for their preparation. The ability to perform mathematical calculations and some understanding of valence is necessary.

Solution concentrations are expressions of the amounts of substances in solution. The expression of concentration is always in relation to the volumes or masses of other parts of the solution. One method of expressing solution concentration is to indicate the concentration in amounts that react chemically. *Molar* solutions and *normal* solutions are expressions of concentration in chemical terms.

Molar Solutions

Molarity is the number of gram molecular weights of a compound per liter of solution. This concentration may also be expressed as the number of *moles* per liter of solution. The molecular weight expressed in grams is equal to one mole of the compound.

The molecular weight is computed by first calculating the atomic weights of all the elements in the compound. This information can be obtained easily by looking at a table of atomic weights in a chemistry text. The molecular weight is determined by adding the weights of all the atoms contained in a compound.

The correct formula of the compound must be known. This information is printed on reagent bottles or it may be found in a handbook of chemistry. The number of moles can be determined by dividing the number of grams of the compound present by the molecular weight in grams.

EXAMPLES

1. The formula for hydrochloric acid is HCl. This indicates that hydrochloric acid contains 1 atom of hydrogen and 1 atom of chlorine. The gram molecular weight is equal to the sum of the atomic weights.

$$H = 1$$
$$Cl = 35.5$$
$$\text{Gram molecular weight} = 36.5 \text{ g}$$

One mole of hydrochloric acid weighs 36.5 g. A 1 molar *(M)* solution contains 36.5 g of HCl per liter.

2. The formula for sodium carbonate is Na_2CO_3. This indicates that sodium carbonate contains 2 atoms of sodium, 1 atom of carbon, and 3 atoms of oxygen. The gram molecular weight is determined in a similar way to that of HCl in example 1.

$$2\ Na = 23 \times 2 = 46$$
$$1\ C = 12 \times 1 = 12$$
$$3\ O = 16 \times 3 = 48$$
$$\text{Gram molecular weight} = 106 \text{ g}$$

One mole of sodium carbonate weighs 106 g. A 1*M* solution contains 106 g of Na_2CO_3/liter.

For practical purposes it is not always necessary to prepare solutions in liter quantities. The student should realize that it is sometimes necessary to scale down the quantities used or to use multiple quantities for greater volumes.

The following formulas may be used to calculate molarity:

$$\text{Molarity} = \frac{\text{number of grams of solute}}{\text{molecular weight in grams}} \times \frac{1}{\text{liters of solution}}$$

Substitution and rearrangement gives us

$$\text{Molarity} = \frac{\text{number of moles of solute}}{\text{liters of solution}}$$

Normal Solutions

It is often necessary to make a comparison of solution strengths. When this is desirable, the solution concentrations should be expressed in terms of *normality*. Normality requires an understanding of *equivalents* and *equivalent weights*.

Normality describes the number of equivalent weights per liter of solution. Normal solutions are also called *equivalent solutions*. An equivalent weight is the weight in grams of a substance that will replace one gram atomic weight (atomic weight in grams) of hydrogen ions (H^+).

PROCEDURE Fill the buret above the zero mark, and adjust the meniscus to exactly zero by manipulating the stopcock. The tip of the buret must be completely filled and free of trapped air bubbles or plugs. For the titration of samples the following procedure should be used:

1. Using a volumetric pipet, carefully pipet the solution to be titrated into an Erlenmeyer flask.
2. Add the required amount of indicator.
3. Add the titrant from the buret to the solution in the flask by manipulating the outflow of titrant with the stopcock.

The procedure for manipulating the buret stopcock is somewhat awkward at first. A right-handed person must use the left hand for this operation. The thumb and index finger are usually used. The solution in the flask is mixed by swirling with the right hand. The meniscus must be adjusted to zero, and this reading should be recorded before starting the titration.

4. Add the titrant in rapid drops at first. As the end point is approached, add only portions of a drop. This is called *splitting drops*.
5. Titrate to the appearance of a faint, but lasting color. This procedure should be followed unless specific instructions indicate otherwise.
6. Record the buret reading. (See Fig. 3-2.)

It is sometimes advisable to waste one sample so the approximate end point may be determined. Two samples should be titrated and the average of the two should be used to calculate the concentration of the sample. Upon completion of the titration, the buret should be rinsed well with tap water and then with distilled or deionized water.

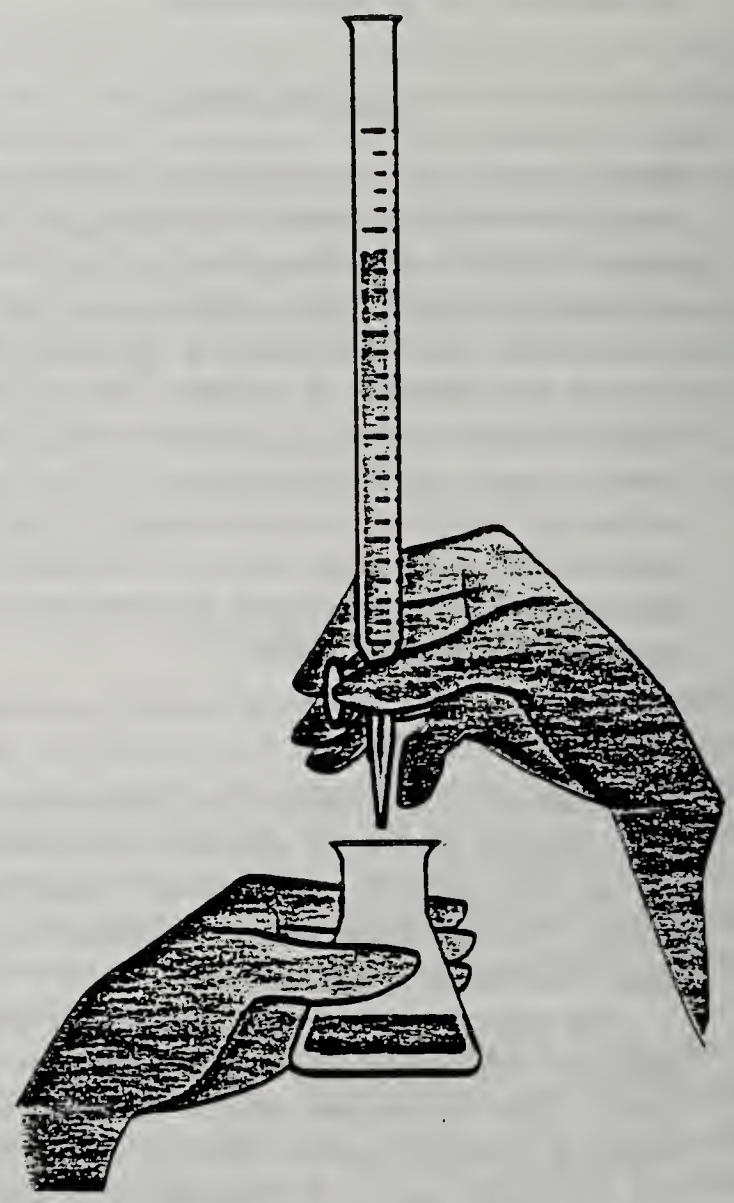

FIGURE 3-2. Technique for using a buret for titration. Manipulate the stopcock with one hand while gently mixing the solution contained within the flask with the other hand.

QUALITY CONTROL

Clinical laboratory tests must be precise, accurate, and reliable to be useful in diagnosing disease. By precise, we mean each test result must be exact, clearly stated, and well defined. To be accurate, each test result must be free from error. Results are reliable if they can be repeated with the same degree of precision and accuracy time after time.

All test results are variable to some degree. The degree of acceptable variation from the normal value is based mainly on statistics. When much information is assembled about a particular physiological pattern, it is possible to determine a suitable range of normal and abnormal values. One aspect of quality control is to make sure that the source of test result variability is due to pathology and not a problem in the design, application, or performance of the procedure.

Assessment of accuracy is another major concern of quality control. We have seen that variability of physiological systems provides no absolute, correct values for measurements made in the laboratory. Accuracy can be determined by comparing the results obtained on the same sample by another equally competent and experienced worker.

Accuracy can also be determined by comparing the value of a standard and previously known sample against results obtained by the worker when using

two liquids. The concentration is expressed as milliliters per unit volume of solution. Volume per unit volume is denoted as milliliters per milliliter (ml/ml) or milliliters per liter (ml/l).

EXAMPLE Prepare 500 ml of acetic acid with a concentration of 0.25 ml/ml. A simple proportion may be used to solve this problem, as follows:

$$\frac{0.25 \text{ ml}}{1 \text{ ml}} = \frac{x \text{ ml}}{500 \text{ ml}}$$
$$x = 125 \text{ ml}$$

Thus 125 ml of acetic acid is measured and diluted to a final volume of 500 ml.

Weight/weight is an expression of concentration that is seldom used. Whenever solid chemicals are mixed or diluted with other solids this notation is indicated. Weight per unit weight is expressed as milligrams per milligram (mg/mg) or grams per gram (g/g).

Procedures and the Preparation of Reagents

Commercially prepared, preweighed packages of solutions are finding widespread use in the laboratory. These solutions are highly recommended for laboratories that use automated procedures. Consumption of reagents in these laboratories is far greater than in those that use manual procedures. The time saved in reagent preparation probably offsets the cost. Yet students must realize that even with the use of commercially prepared reagent packets, some reagents will still have to be prepared.

Only chemicals of the highest degree of purity should be used in the clinical laboratory. Reagents designated as pure contain only the compound described with no impurities used as fillers. *Analytical reagent grade (AR)* compounds are of the highest degree of purity. Those designated as *American Chemical Society (ACS)* meet the standards of the American Chemical Society for analytical grade reagents. *Chemically pure (cp)* grade reagents have purity that is generally suitable for clinical laboratory purposes. Look for one of these designations to be sure of using suitable reagents.

GENERAL PROCEDURES The basic characteristics and hazards of reagents are always printed on container labels. Proper and safe handling and storage practices should be followed for chemicals used in the laboratory. The following includes some fundamental rules:

1. Replace the covers of all reagent bottles promptly and securely.
2. Store dry chemicals in a cool, dry place.
3. Store flammable materials in a cool area removed from open flames or sparks.
4. Handle volatile substances and substances that produce irritating fumes under a fume hood.
5. Dry substances that absorb moisture in a drying oven or desiccator prior to weighing. Failure to remove this moisture will result in an incorrect weight.

Quantitative Transfer

Precise weighings and measurements that are practiced in the clinical laboratory require the use of the technique called *quantitative transfer*. This technique ensures that the entire amount of substance that is weighed or measured will actually be incorporated into the substance being prepared.

The technique of quantitative transfer is used when a solid or a liquid is transferred from one container to another and is especially important when dilution to a specified volume must be made.

Quantitative transfer should be performed in a section of the laboratory that is free from pedestrian traffic and air currents. All glassware and materials should be assembled. A wash bottle should be filled with the appropriate diluent.

Chemicals are usually weighed into beakers or onto weighing paper. The object of performing a quantitative transfer is to transfer the entire quantity from the weighing vessel or paper to the flask for final dissolution and dilution.

Whenever possible the chemical should be mixed and dissolved in the weighing vessel. This step will facilitate the transfer to the volumetric flask. When a glass stirring rod is used it should remain with the weighing vessel until the transfer is complete.

The volumetric flask should be fitted with a clean, dry funnel. The solid or dissolved material must be

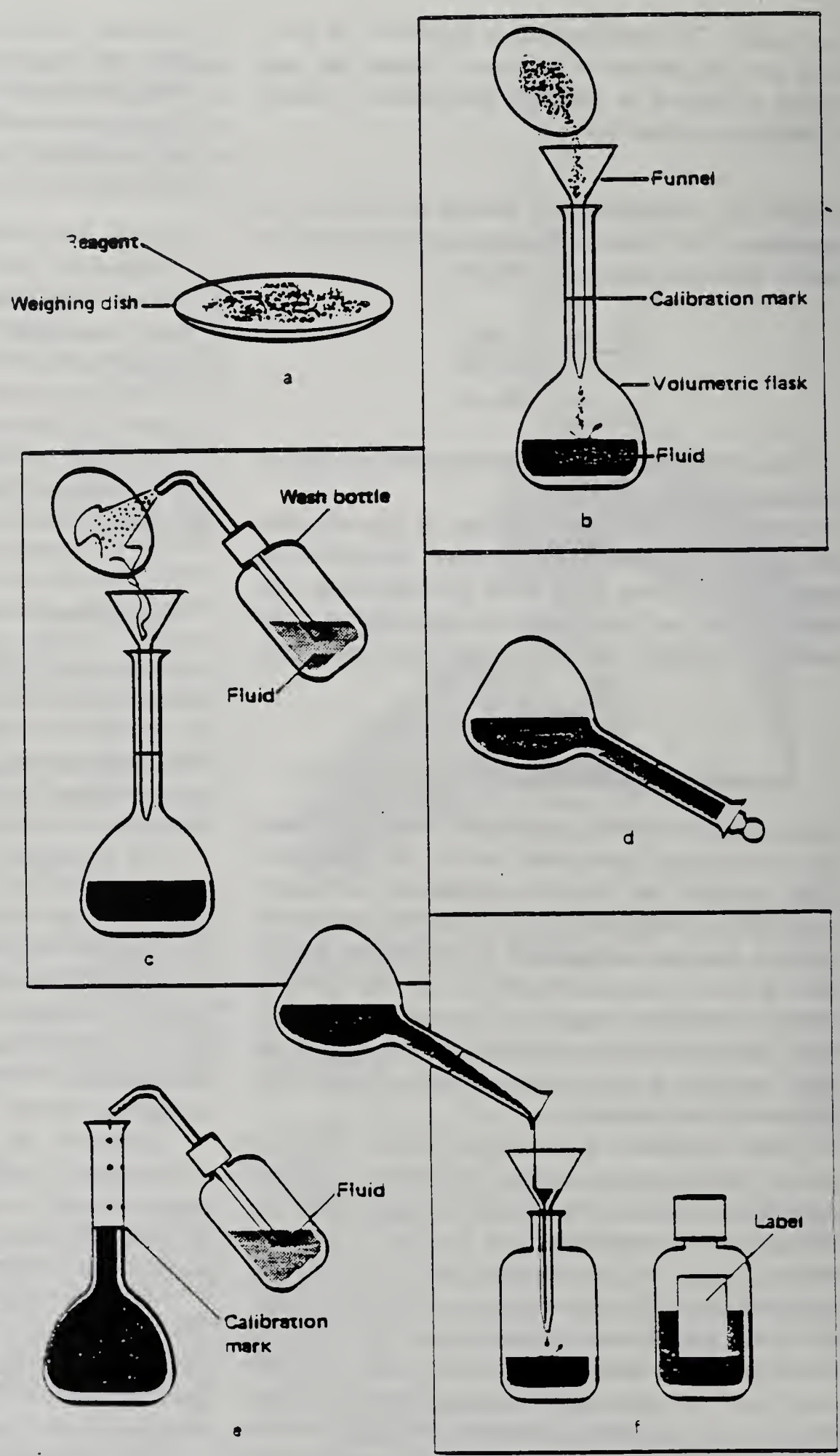

FIGURE 3-1. Quantitative transfer technique. (*a*) Weigh reagent. (*b*) Empty the reagent using a funnel into a volumetric flask containing some liquid. (*c*) Use a wash bottle several times to remove all reagent from the dish. (*d*) Invert or shake to mix. (Remember to place the cap on the flask before mixing.) (*e*) Fill the flask to the calibration mark using more liquid and mix again. (*f*) Pour the reagent solution into the stock bottle and label.

carefully transferred, *without any loss*, to the funnel in the flask. With the lip of the beaker held in place at the funnel, carefully rinse the inside of the beaker with small portions of diluent using a wash bottle.

Repeat this procedure approximately five times, or until all visible evidence of the solid is gone. Add all rinsings to the volumetric flask. Rinse the funnel with the diluent and remove it from the flask. Add a sufficient amount of diluent to the flask to bring about dissolution of the solid. Be sure that all of the solid is dissolved. Allow for cooling to room temperature if heat is evolved or applied during the process.

Add diluent to within one inch of the calibration mark. Carefully add additional diluent to adjust the level of liquid. The bottom of the meniscus must be *exactly* even with the calibration mark. Stopper the flask and invert it several times to mix the contents. (See Fig. 3-1.)

TITRATION

Clinical laboratory methods frequently require that the concentration of substances be determined using volumetric techniques. Such procedures are used to calculate the volume of a reagent solution needed to react with a specific volume of a sample. The sample may be a biological fluid or an extract of a biological fluid. Sometimes the sample is simply another reagent. The technique that may be used for this process is *titration*.

Concept of Titration

Titration requires the addition of a solution of known concentration, called a *standard*, to an accurately measured volume of sample. The reagent or standard is added dropwise, usually from a buret, until a sudden change is noticed in the appearance of the solutions being mixed.

The change may be indicated by the appearance of a precipitate. If a chemical indicator is used a color change will occur. A precise change in pH is sometimes required that can be monitored with a pH meter. When a noticeable change occurs, the *end point* of the reaction has been reached and the desired concentration determined. End points must be approached carefully to avoid overtitrating.

TABLE 3-9 *Chemical indicators used in the clinical laboratory for titration*

INDICATOR	pH RANGE	COLOR CHANGE	
		ACID	ALKALINE
Töpfer's reagent	2.8–4.0	Red	Yellow
Congo red	3.0–5.0	Blue	Red
Methyl orange	3.1–4.4	Red	Yellow
Phenol red	6.8–8.4	Yellow	Red.
Phenolphthalein	8.3–10.0	Colorless	Red

Concentrations of standard solutions are usually expressed in normality, and the concentration of the sample solution may then be directly compared and calculated. Titration is frequently used in the preparation of various reagents and in some clinical procedures described in other sections of this book.

Selection of Indicators

The end point of a titration reaction is often determined by using a chemical *indicator*. Indicators are usually weak acids or weak bases that ionize to form a color different from the undissociated (not ionized) form. Chemical indicators respond to changes in hydrogen ion concentration and therefore detect changes in solution pH.

The choice of which indicator to use for a specific procedure will require a thorough knowledge and understanding of the pH range present at the end point of the reaction. The methodologies supplied for laboratory procedures usually list the indicator to be used and the end point to be expected (See Table 3-9.)

Procedures

A clean, calibrated buret or similar device must be used. The buret and its capillary tip must be free from cracks and chips. During the titration procedure a buret clamp and stand are used to secure the buret. The buret stopcock must turn easily and smoothly.

Prior to using the buret it must be rinsed well with the solution that it will contain. This solution is called the *titrant*. Rinsing can be done easily by filling the buret and allowing the titrant to drain. This process should be repeated several times. The rinse solution should always be discarded.

The equivalent weight of a compound is determined by first computing the gram molecular weight. The gram molecular weight must then be divided by the valence of the positive ion(s) in the compound. Other useful terms that describe normality include milliequivalents per liter (meq/l) or milliequivalents per milliliter (meq/ml).

EXAMPLES

1. The formula for potassium chloride is KCl. This compound ionizes in solution to form 1 K^+ (potassium ion) and 1 Cl^- (chloride ion). The positive valence is +1. The equivalent weight for this compound is equal to the molecular weight, as follows:

$$\text{Equivalent weight} = \frac{\text{molecular weight}}{+1}$$

2. The formula for sulfuric acid is H_2SO_4. This compound ionizes in solution to form $2H^+$ and 1 complex sulfate ion $(SO_4)^-$.

The total positive charge on this molecule is 2. The equivalent weight for sulfuric acid is equal to the molecular weight divided by 2.

The following formulas may be used to calculate normality:

$$\text{Normality} = \frac{\text{number of grams of solute}}{\text{gram molecular weight/ total positive charge}} \times \frac{1}{\text{liters of solution}}$$

Substitution and rearrangement gives us,

$$\text{Normality} = \frac{\text{equivalents of solute}}{\text{liters of solution}}$$

Percent Solutions (%)

Percent solutions are an expression of concentration as parts per hundred. Solid or liquid chemicals may be used for the preparation of percent solutions. When the solute is a solid, the percent solution denotes grams of solute per 100 ml of solution (g/100 ml). When a liquid chemical is used, the percent solution denotes milliliters per 100 ml of solution (ml/100 ml).

Some solids are weighed in milligram quantities and diluted to 100 ml. The concentration is expressed as milligrams percent (mg%). This notation is frequently used to express the concentration of standard solutions. The more current notation, milligrams per deciliter (mg/dl), is replacing milligrams percent.

EXAMPLES

1. 50 ml of hydrochloric acid (HCl) is diluted to 100 ml in a volumetric flask. What is the concentration in percent?

$$\frac{50 \text{ ml}}{100 \text{ ml}} \times 100 = 50\%$$

2. 40 g of sodium chloride (NaCl) is diluted to 250 ml. What is the concentration in percent? A simple proportion may be used to solve this problem, as follows:

$$\frac{40 \text{ gm}}{250 \text{ ml}} = \frac{x \text{ gm}}{100 \text{ ml}}$$
$$250x = 4000$$
$$x = 16\%$$

Weight/Volume Solutions

These solutions are an expression of concentration as the amount of solute per unit volume. This notation is used when a solid is dissolved and diluted in a liquid. Weight per unit volume is expressed as grams per liter (g/l) or milligrams per milliliter (mg/ml).

EXAMPLE

Prepare 200 ml of a solution containing 25 mg/ml. This problem may be solved by using a simple proportion:

$$\frac{25 \text{ mg}}{1 \text{ ml}} = \frac{x \text{ mg}}{200 \text{ ml}}$$
$$x = 5000 \text{ mg or } 5 \text{ g}$$

Thus 5 g of the solute is weighed and diluted to 200 ml in a volumetric flask.

Volume/Volume

Another type of solution, volume/volume, is an expression of concentration used for the dilution of

that standard in the clinical procedure. We may assume that the values of all unknown samples are free from error if results from testing the standard conform to its expected value.

There is a direct relationship between the reliability of laboratory test results and the technical competence and experience of the staff. Many sources of error are traceable to worker carelessness, either sloppy procedure or incorrect use of equipment, supplies, and reagents. Other sources of error include defective equipment and incorrect patient identification and reporting.

Worker Carelessness

A major source of error in the clinical laboratory is worker carelessness, which can develop in even the most highly trained individuals.

Performance of routine procedures over a long period of time can lead to monotony and overconfidence. When we become overconfident, we tend to rely more upon memory than upon printed procedures. Distraction and boredom frequently cause careless habits to develop. All laboratory workers must avoid these pitfalls and attempt to maintain work habits and attitudes that prevent these weaknesses from developing.

Deviations from proven procedures and unorthodox innovations are probably the most common examples of worker carelessness. Laboratory data must be recorded as it is collected. Do not rely on memory. Perform mathematical calculations carefully, avoid time pressures, and always double check your work.

Defective Equipment and Supplies

All laboratory workers have the responsibility of using equipment and supplies that are free of defects. Frequent inspection of equipment and supplies should be made. Newly received materials should be inspected for defects in workmanship and design. It is not uncommon in this age of mass production to receive equipment that is defective in one way or another. Defects can also develop during shipment and handling.

Pipets and volumetric glassware should be inspected and checked prior to their use. Pipets with broken or chipped tips must be discarded. Check bottled reagents for expiration date and breakage.

Electronic equipment should be tested and calibrated prior to actual use. Most manufacturers provide detailed instructions for the calibration of their instruments. Replace broken or damaged parts and keep a supply of spare parts on hand.

Use of Uncalibrated Instruments or Glassware

All glassware used for diluting or preparing reagents and measuring samples must be calibrated. Analytical results depend upon exact quantities or *aliquots*. An aliquot is a carefully measured sample that is considered representative of the entire specimen. Use of uncalibrated glassware or equipment in analytical work will lead to errors and yield unreliable results.

Incorrect Use, Formulation, or Contamination of Reagents

Laboratory tests require specific materials and reagents. The reagents used must be prepared according to specific instructions and techniques. Some reagents may be used for more than one test. Others are highly specialized and their use is unique for detection of certain substances.

Careful attention must be given to the ingredients that go into the formulation of reagents and to the instructions for their preparation. Each constituent has been selected, and the quantity necessary for reaction has been determined on the basis of scientific principles and research. Accuracy will be affected by improperly prepared reagents. Chemical reactions may not occur or they may not proceed to completion.

Reagents of the correct concentration must be used, and these reagents must be added to a reaction mixture in a specific order. Desired reactions may also depend upon the mixture's being at a specific pH.

Reagents used in clinical tests must always be free of contamination. Check for bacterial contamination in liquid reagents. Turbidity (cloudiness) is a sign of bacterial growth. Dry reagents must be inspected for contamination by moisture and deterioration caused by heat. Reagents must be pure and uncontaminated by other laboratory substances. Always use clean containers to prepare and store reagents, and provide complete labels for each of these containers.

Incorrect Patient Identification and Reporting

One of the greatest responsibilities facing laboratory staff members is proper identification of patients, their specimens, and their laboratory reports. Misidentification of patients and their results may cause the death or discomfort of a patient. Mismatched blood transfusions may be given accidentally, treatments may be withheld, or unnecessary treatments may be administered.

Identification systems used in the laboratory should be clearly understood by all workers. Frequently used systems may vary slightly from one institution to another. Usually an identifying number, such as the patient's social security number, is assigned to the individual. Other information, such as date of birth, sex, and address may be encoded. Whatever the number, it is unique and remains with the patient for all visits to the institution.

Hospital patients are usually assigned an identification bracelet and a bed card. The laboratory ordinarily follows directions written on a laboratory request slip. All information on this slip must be verified prior to collection of the specimen. If errors are discovered, the nurse in charge must be contacted and asked for verification of the information. Unidentified or unlabeled specimens received by the laboratory must be returned.

All equipment and supplies should be identified and labeled at the patient's bedside. Identification of infants, children, and foreign-speaking patients must be carefully determined. When in doubt about correct identification, ask your superior. Never be afraid to question positive identification of the sample.

Inherent Limitations of Clinical Tests

Every test performed in the clinical laboratory has limitations that must be recognized. These limitations may be based on factors related to the tests themselves, or to random errors on the part of the worker, the materials, or the equipment, which cannot easily be controlled. Laboratory results are, at best, estimations.

One major limiting factor is the *specificity* of the procedure. We may ask questions: Is the procedure measuring all of the desired substance present in the sample? Is it measuring other unrelated compounds that are present? How much do other substances interfere with the measurement of the desired substance?

The size of the sample actually used in comparison with the amount available may be a source of error. We usually collect a sample of several milliliters of blood, for example, yet in some instances only a few cubic millimeters are analyzed. Is this very small sample typical of all the blood in the body?

The use of so-called normal values, which provide us with a basis for comparison, is a major concern to some clinicians. Some advocate the establishment of normal values by each laboratory rather than relying on a set of normal values used by all laboratories in the country. Normal values depend upon the group that is sampled. Geographical location, patterns of living, age group, and the number of people sampled are all factors that influence establishment of normal values. Locally obtained normal values may more accurately reflect the results to be expected from other members of that population.

Control Methods

The physician depends on the results of clinical laboratory determinations for the diagnosis and treatment of disease. Faced with this responsibility, the medical laboratory utilizes several procedures to ensure the precision, accuracy, and reliability of results.

One of the simplest ways of checking reliability is the use of *duplicate analyses*. Limits can be established for allowable variation. Values that fall within these allowable limits are acceptable. Values that exceed the acceptable limits are rejected. These limits are calculated by statistical methods.

Another means of ensuring accuracy of results is through the use of *control solutions*. It is customary procedure to run *low*, *normal*, and *high* controls on a daily basis. This means that standard solutions are used that have been analyzed previously and will give a range of normal results. The controls are routinely included and analyzed with the patient samples. Three types of controls are used: reagent blanks, standard solutions, and reference materials.

Reagent blanks are usually run as a means of correcting for color or characteristics that might occur as natural phenomena. This may be caused by indi-

vidual reagents or an interaction between the reagents used in the test.

Standard solutions provide the basis for comparison of test samples with the pure substance under investigation. Standard solutions are solutions of known concentrations that enable us to make our comparison.

Reference materials are usually human sera or plasma that have been assayed by an independent laboratory or analyst. These materials are often used as a control.

The primary purpose of using a control is to check reagents, standards, technique, and equipment. Control solutions are subjected to the same conditions and treated with the same reagents as the test samples. The reliability of results can be judged if the "correct" value of the control is known. Controls are always run with each batch of tests.

Commercially prepared controls are available. These materials are usually dehydrated samples of pooled human sera or plasma. The pools are assayed by the manufacturer, and the values are provided for a variety of constituents.

Since the samples are taken from human pools, they contain a variety of constituents. Each vial can be used for more than one determination. The ranges of acceptable values are supplied by the manufacturer. Results for control samples must be within the limits of acceptable value before any test samples can be reported.

Many laboratories prefer to prepare their own control solutions. This can easily be done by pooling all leftover normal serum or plasma samples. Several liters are usually collected. Individual samples must be preserved by freezing. The normal average value is determined by running approximately 25 individual tests on a daily basis.

Statistics are used to determine the expected range of values for the control. A control sample is then included with each batch of determinations.

Another method of using controls is to prepare a visual chart known as a *quality control chart*. Acceptable limits are indicated on the chart and it permits immediate determination, by visual means, as to whether or not a value is acceptable. Trends leading toward incorrect values can be readily observed and possibly forestalled. The use of control materials is not limited to the chemistry laboratory. These items are available for urinalysis, hematology, bacteriology, serology, and blood banking.

Standard Solutions

An essential part of all laboratory tests are *standard solutions*. They provide a basis for comparison or a frame of reference. Standards are prepared from chemically pure substances. They must be accurately weighed and diluted to an exact volume. When handled in this way the final concentration is exact. Volumetric glassware is used and weighing is performed on an analytical balance.

The standards used in chemical analysis may be obtained from the National Bureau of Standards. Certificates listing the purity of the compounds are usually supplied with these standards. A standard may be prepared as an *aqueous solution*, *an intermediate product*, or some artificial substance such as a dye. Standards are often processed in the same way and with the same reagents as the patient samples or controls. However they are introduced into the test system, their purpose is one of comparison of test samples with that of the standard.

Internal standards are prepared by adding a known amount of pure substance to one of the samples under analysis. This is sometimes done to introduce factors present in samples that are not present in aqueous standard solutions.

Most standards are prepared in concentrated form called *stock standards*. Dilutions of the stock standard, using quantitative technique, are used during analysis. The diluted form of the stock standard is called a *working standard*. Quantitative technique must be used in handling all standard materials, since the results of the analysis depends on the standard concentration.

JOB SHEET

555-001-002

"REVIEW SOLUTIONS"

Select the BEST answer.

1. Preparation of solutions requires the use of_____glassware.

   A. graduated
   B. volumetric
   C. serological
   D. measured

2. _____are substances, usually liquids, that dissolve a solid.

   A. Solutes
   B. Solvents
   C. Solutions
   D, Molars

3. Solutes, such as salts, break into changed particles called _____.

   A. electrolytes.
   B. ions.
   C. molecules.
   D. atoms.

4. _____is the number of gram molecular weights of a compound per liter of solution.

   A. Solutions
   B. Suspensions
   C. Scales
   D. Molarity

5. This formula may be used to calculate molarity:

$$\text{Molarity} = \frac{\text{number of grams of solute}}{\text{molecular weight in grams}} \times \frac{1}{}$$

   A. liters of solution
   B. gram molecular weight.
   C. liter quantities.
   D. equivalent weights.

6. The following formula may be used to calculate normality:

$$\text{Normality} = \frac{\dfrac{\text{gram molecular weight/total positive change}}{\text{X}}}{\dfrac{1}{\text{liters of solution}}}$$

A. equivalents of solute.
B. number of grams of solute
C. number of moles of solute
D. molecular weight in grams

7. The chemical with the highest degree of purity used in the clinical laboratory is

A. chemically pure.
B. analytical reagent grade.
C. saturated solution.
D. chemical reagent grade.

8. Some fundamental rules to follow when handling and storing chemicals include replacing covers, storing flammables in a cool area, handling volatile substances under a fume hood, and storing dry chemicals in a _____place.

A. cool, dry
B. wet, moist
C. cool, moist
D. flat, cool

9. This technique assures precise_____weighings and measurements that are practiced in the clinical laboratory.

A. qualitative analysis
B. quantitative transfer
C. pipetting technique
D. qualitative transfer

10. The technique used to calculate the volume of a reagent solution needed to react with a specific volume of a sample is

A. quantitative transfer.
B. quality control.
C. standard solutions.
D. titration.

11. Titration requires the addition of a solution of known concentration called a _____, to an accurately measured volume of sample.

A. indicator
B. titrant
C. solvent
D. standard

12. The end point of a titration reaction is often determined by using a chemical _____, weak acids or weak bases.

A. base
B. indicator
C. reagent
D. standard

13. For the titration procedure a clean, calibrated _____or similar device must be used.

A. tube
B. flask
C. pipette
D. buret

14. Clinical laboratory _____must be precise, accurate and reliabe to be useful in diagnosing disease.

A. procedures
B. tests
C. methods
D. preparations

15. The major source of error in the clinical laboratory is worker _____, which can develop in even the most highly trained individuals.

A. overconfidence
B. performance
C. calculations
D. carelessness

16. Equipment and supplies used by all laboratory workers are to be free of _____.

A. defects.
B. inspection.
C. breakage.
D. overuse.

17. All glassware used for diluting or preparing reagents and measuring samples must be

    A. pre-examined.
    B. calibrated.
    C. non-breakable.
    D. stored.

18. To insure liquid reagents used in clinical tests be free of bacterial contamination, check for _____, a sign of bacterial growth.

    A. odor
    B. moisture
    C. deterioration
    D. turbidity

19. One of the greatest responsibilities facing laboratory staff members is proper _____ of patients, their specimens and their laboratory reports.

    A. identification
    B. recognition
    C. clarification
    D. recording

20. Several procedures ensuring precision, accuracy and reliability of results of clinical laboratory determinations are duplicate analysis, reagent blanks, control solutions, reference materials, and

    A. stock standards.
    B. quantitative transfers.
    C. standard solutions.
    D. prepared samples.

INTERMEDIATE OBJECTIVE #2

Prepare solutions

LEARNING STEPS (Activities)

1. Observe Resource #1 for demonstration on titration of samples.
2. Practice preparing solutions by using Resource #2 as a guide.
3. For mastery of this task, complete Resource #3.
4. Complete Resource #4 for a written evaluation.
5. Proceed to Resource #5.

RESOURCES

1. See instructor.
2. Job Sheet 555-002-002, "Practice Titration", page 19 in this learning guide.
3. Performance Checklist, pages 20-21 in this SLG.
4. Written Criterion Exam, Task #555, "Prepare Solutions," in the LRC. See instructor for evaluation.
5. See instructor for next learning guide.

JOB SHEET

555-002-002

"PRACTICE TITRATION"

Directions to the student:

With the necessary equipment and supplies practice titration.

Necessary equipment and supplies:

Volumetric pipet
Erlenmeyer flask
Buret with stopcock
Titrant
Distilled water

Procedure:

1. Using a volumetric pipet, carefully pipet the solution to be titrated into an Erlenmeyer flask.
2. Add the required amount of indicator.
3. Add the titrant from the buret to the solution in the flask by manipulating the outflow of titrant with the stopcock.
   The procedure for manipulating the buret stopcock is somewaht awkward at first. A right handed person may use the left hand for this operation. The thumb and index finger are usually used. The solution in the flask is mixed by swirling with the right hand. The meniscus must be adjusted to zero, and this reading should be recorded before starting the titration.
4. Add the titrant in rapid drops at first. As the end point is approached, add only prtions of a drop. This is called <u>splitting drops</u>.
5. Titrate to the appearance of a faint, but lasting color. This procedure should be followed unless specific instructions indicate otherwise.
6. Record the buret reading (See Fig. 3-2).

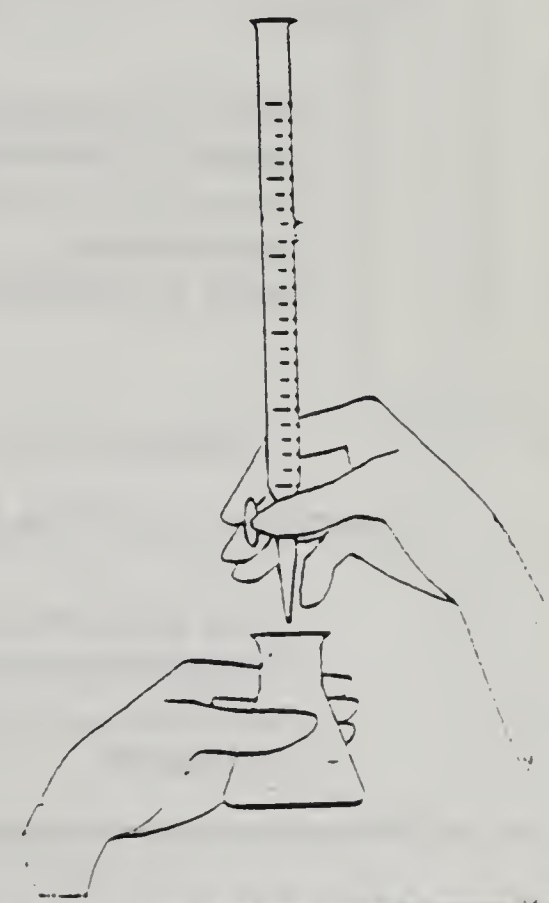

FIGURE 3-2 Technique for using a buret for titration. Manipulate the stopcock with one hand while gently mixing the solution contained within the flask with the other hand.

PERFORMANCE/PRODUCT CHECKLIST

Program: MEDICAL ASSISTING

Task No: 555

Student's Name: _____ Date Of Attempt: _____

Evaluator's Name: _____ Evaluation Site: _____

Performance Attempt: 1 2 3 4

Terminal Performance Objective:

Given the necessary equipment and supplies, prepare solutions.

Directions To The Student:

Before attempting this task for mastery, carefully review this checklist. You will be evaluated on the basis of this checklist. When you feel you are ready for evaluation, contact your instructor. You must complete your performance within _____ minutes and must score at least _____ out of _____ points or _____ % for mastery. Critical items are marked with an asterisk (*). These items must be satisfactorily completed.

Directions To The Evaluator:

The student will contact you when ready for the evaluation. The student must complete the performance within _____ minutes and must score _____ out of _____ points or _____ % and all items marked with an asterisk (*) must be satisfactorily completed.

CRITICAL ITEMS	ITLMS TO BE OBSERVED OR CHECKED	RATING YES	RATING NO
*	1. Pipet with a volumetric pipet into an Erlenmeyer flask.		
*	2. Add the required amount of indicator.		
*	3. Add the titrant from the buret to the solution in the flask by manipulating the buret stopcock.		
*	4. Add the titrant in rapid drops at first.		
*	5. As end point is approached, add only prtions of a drop.		
*	6. Titrate to a fast, but lasting color.		
*	7. Record the buret reading.		
	TOTAL POINTS EARNED =		

POINTS NEEDED FOR MASTERY = 7
TOTAL POINTS POSSIBLE = 7

PROGRAM MEDICAL ASSISTING

CRITERION EXAM

TASK = 555

DIRECTIONS:

THE PURPOSE OF THIS EXAM IS TO DETERMINE WHETHER OR NOT YOU HAVE UNDERSTOOD THE INFORMATION ON **PREPARING SOLUTIONS.**

Each of the questions or incomplete statements below is followed by several words, phrases, or a series of numbers. Choose the one which best answers the question or completes the statement correctly. Place the letter associated with that choice (A,B,C or D) in the numbered blank space on your ANSWER SHEET. DO NOT WRITE ON THIS TEST!!! To master this exam you must answer 19 out of 20 items correctly, 90 %.

EVALUATION SHEET

WRITTEN CRITERION EXAM
"PREPARE SOLUTIONS"

Select the BEST answer.

1. Solutes, such as salts, break into changed particles called _____.

   A. electrolytes.
   B. ions.
   C. molecules.
   D. atoms.

2. The chemical with the highest degree of purity used in the clinical laboratory is

   A. chemically pure.
   B. analytical reagent grade.
   C. saturated solution.
   D. chemical reagent grade.

3. Preparation of solutions requires the use of _____glassware.

   A. graduated
   B. volumetric
   C. serological
   D. measured

4. Equipment and supplies used by all laboratory workers are to be free of _____.

   A. defects.
   B. inspection.
   C. breakage.
   D. overuse.

5. One of the greatest responsibilities facing laboratory staff mem-ers is proper _____of patients, their specimens and their laboratory reports.

   A. Identification
   B. recognition
   C. clarification
   D. recording

6. _____are substances, usually liquids, that dissolve a solid.

   A. Solutes
   B. Solvents
   C. Solutions
   D. Molars

EVALUATION SHEET

WRITTEN CRITERION EXAM (Cont.)

7. This formula may be used to calculate molarity:

$$\text{Molarity} = \frac{\text{number of grams of solute}}{\text{molecular weight in grams}} \times \frac{1}{\qquad\qquad}$$

A. liters of solution.
B. gram molecular weight.
C. liter quantities.
D. equivalent weights.

8. This technique assures precise _____ weighings and measurements that are practiced in the clinical laboratory.

A. qualitative analysis
B. quantitative transfer
C. pipetting technique
D. qualitative transfer

9. To insure liquid reagents used in clinical tests be free of bacterial contamination, check for _____, a sign of bacterial growth.

A. odor
B. moisture
C. deterioration
D. turbidity

10. For the titration procedure a clean, calibrated _____ or similar device must be used.

A. tube
B. flask
C. pipette
D. buret

11. _____ is the number of gram molecular weights of a compound per liter of solution.

A. Solutions
B. Suspensions
C. Scales
D. Molarity

EVALUATION SHEET

WRITTEN CRITERION EXAM (Cont.)

12. The following formula may be used to calculate normality:

$$\text{Normality} = \frac{\text{gram molecular weight/total positive change}}{} \times \frac{1}{\text{liters of solution}}$$

A. equivalents of solute.
B. number of grams of solute
C. number of moles of solute
D. molecular weight in grams

13. Clinical laboratory _____ must be precise, accurate and reliable to be useful in diagnosing disease.

A. procudures
B. tests
C. methods
D. preparations

14. Several procedures ensuring precision, accuracy and reliability of results of clinical laboratory determinations are duplicate analysis, reagent blanks, control solutions, reference materials, and

A. stock standards.
B. quantitative transfers.
C. standard solutions.
D. prepared samples

15. Some fundamental rules to follow when handling and storing chemicals include replacing covers, storing flammables in a cool area, handling volatile substances under a fume hood, and storing dry chemicals in a _____ place.

A. cool, dry
B. wet, moist
C. cool, moist
D. flat, cool

16. Titration requires the addition of a solution of known concentration called a _____, to an accurately measured volume of sample.

A. indicator
B. titrant
C. solvent
D. standard

17. The technique used to calculate the volume of a reagent solution needed to react with a specific volume of a sample is

    A. quantitative transfer.
    B. quality control.
    C. standard solutions.
    D. titration.

18. All glassware used for diluting or preparing reagents and measuring samples must be

    A. pre-examined.
    B. calibrated.
    C. non-breakable.
    D. stored.

19. The point of a titration reaction is often determined by using a chemical _____, weak acids or weak bases.

    A. base
    B. indicator
    C. reagent
    D. standard

20. The major source of error in the clinical laboratory is worker _____. which can develop in even the most highly trained indeviduals.

    A. overconfidence
    B. performance
    C. calculations
    D. carelessness

APPENDIX IV

Secretarial Office Occupations Learning Guides

Illinois State Board of Education

Department of Adult, Vocational and Technical Education
Research and Development Section

Product Abstract

1. Title of material 9 Secretarial Office Occupations Learning Guides - titles listed on reverse side

2. Date material was completed FY85

3. Please check one: New material X Revised material ____ Field-tested material ____

4. Originating agency Lake County Area Vocational Center

   Address 19525 West Washington Street, Grayslake IL Zip Code 60030

5. Name(s) of developer(s) Jan Robinson

   Address Lake County Area Vocational Center Zip Code ____

6. Developed pursuant to Contract Number R-99-25-X-0000-499

7. Subject Matter (Check only one according to Department of Education Code):

   Code

   ____ 01 Agricultural Education
   ____ 03 Business and Office Education
   ____ 04 Distributive Education
   ____ 07 Health Occupations Education
   ____ 09 Home Economics Education
   ____ 10 Industrial Arts Education
   ____ 16 Technical Education
   X 17 Trade and Industrial Education
   ____ 22 Cooperative Education
   ____ Career Education
   ____ Other (Specify) ____

8. Education Level:

   ____ Pre-K Thru 6
   ____ 7-8
   ____ 9-10
   X 11-12
   X Post-Secondary
   X Adult
   ____ Teacher (Pre-service)
   ____ Administrator (Pre-Service)
   ____ Other (Specify) ____

9. Intended for Use By:

   X Student
   X Classroom Teacher
   X Local Administrator
   ____ Teacher Educator
   ____ Guidance Staff
   ____ State Personnel
   ____ Other (Specify) ____

10. Student Type:

    X Regular
    ____ Disadvantaged
    ____ Handicapped
    ____ Limited-English Proficiency
    ____ Other (Specify) ____

11. Medium and Format of Materials:

    X HARDCOPY
    ____ VIDEOTAPE
    ____ FILM
    ____ MICROFICHE

    No. of pages various
    ____ Paper bound
    ____ Hard bound
    X Loose-leaf
    Photos: Yes ____ No ____
    Diagrams: Yes ____ No ____

    ____ Minutes
    ____ B & W
    ____ Color
    ____ inches

    ____ Minutes
    ____ B & W
    ____ Color
    ____ mm

    ____ B & W
    ____ Color

___ SLIDES

No of frames _____
___ B & W
___ Color
___ Audio
___ Carousel provided
___ Other packaging used
(Specify) _____

___ FILM STRIPS

No of frames _____
___ B & W
___ Color
___ Audio

___ AUDIO

___ Automatic synch
___ _____ Hz
___ Manual cue
___ Reel
___ Cassette
___ Cartridge

___ OTHER

Specify _____
_____
_____

12. Availability:

_____ One copy free
X In ERIC system (No. _____)
For sale @ $ _____ per copy
_____ Not available
_____ Loan copy available

Contact: Name East Central Network for Curriculum Coord. Phone (217) 786-6375
Illinois Vocational Curriculum Center
Address Sangamon State University, Building F Zip Code 62708
Springfield IL

13. Copyright Restrictions:

Contact: Name NONE Phone ( )
Address _____ Zip Code _____

14 What level(s) of assistance is required to provide implementation of this outcome?

_____ awareness
X understanding
_____ deciding
X implementing

15. Are Consultive/Inservice (or staff development) available? Yes _____ No _____

Contact: Illinois State Board of Education
Department of Adult, Vocational and Technical Education
Research and Development Section, E-426
100 North First Street
Springfield, IL 62777
(217) 782-4620

16 General Description (State the general objective and suggested method of use. Summarize the content and tell how it is organized. Write the description so that it can be used to promote the material. Continue on back of this sheet or on another sheet, if necessary)

Competency-based learning guides for learning basic skills/knowledge

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LEARNING GUIDE TITLES:

1. Manage files on the OIS 60 Information Processing System
2. Format text on an OIS 60 Information Processing System
3. Edit text on the Wang OIS 60 Information Processing System
4. Copy and move text on a Wang OIS 60 Information Processing System
5. Perform advanced formatting on the Wang OIS 60 Information Processing System
6. Perform advanced printing on the Wang OIS 60 Information Processing System
7. Print documents using the dual column feature on the Wang OIS 60 Information Processing System
8. Merge two documents on the Wang OIS 60
9. Sort data on the Wang OIS 60 Information Processing System

LAKE
COUNTY
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CENTER

COMPETENCY-BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

STUDENT LEARNING GUIDE

Produced By Jan Robinson Date 01/02/85

TASK: Manage files on the OIS 60 Information Processing System.

PURPOSE: Documents should be named logically and filed in an organized manner so they may be easily retrieved. In this guide you will learn the steps required to file, copy, delete, and retrieve documents on an OIS 60 Information Processing System.

INFORMATION PROCESSING

Program	Task	Est.Time	Prereq.
SOO	170.B.5	10 hours	170.B.1-170.B.4

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME _____ SOCIAL SECURITY NUMBER _____

LENGTH OF CONTRACT (NORMAL TIME IN HOURS) _____

2. TERMINAL PERFORMANCE OBJECTIVE

Given the needed supplies, equipment, and data, manage files on an OIS 60 Information Processing System.

To master this task you must score two out of two on a product checklist and score 19 out of 21 on a written exam.

2a. INTERMEDIATE OBJECTIVE(s)

1. Prepare a diskette for use on an OIS 60 Information Processing System.
2. Manage files on an OIS 60 Information Processing System.

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____. I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

Student's Signature _____

Instructor's Signature (verifies competency) _____

INTERMEDIATE OBJECTIVE #1

Prepare a diskette for use on an OIS 60 Information Processing System.

LEARNING STEPS (Activities)

1. To define filing on the OIS 60, see Resource 1.
2. To organize your documents for most efficient filing, see Resource #2.
3. See Resource #3 to identify the parts of a disk.
4. To learn proper disk care, see Resource #4.
5. To learn how to insert disk in disk drive see, Resource #5.
6. See Resource #6 to learn how to prepare a disk for use.
7. See Resource #7 to proceed to Intermediate Objective #2.

RESOURCES

1. Read pages 5-4 and 5-5 in Filing in your Word Processing Training Manual.
2. Read pages 5-6 to 5-7 in your Word Processing Training Manual - Document Filing.
3. Read page 5-8 in FILING in your WORD PROCESSING TRAINING MANUAL.
4. Read pages 5-9 to 5-12 in FILING in your WORD PROCESSING TRAINING MANUAL.
5. See instructor for demonstration.
6. Read pages 5-13 to 5-19 in FILING in your WORD PROCESSING TRAINING MANUAL; complete exercise as directed.
7. See Guide page 4.

INTERMEDIATE OBJECTIVE #2

Manage files on an OIS 60 Information Processing System.

LEARNING STEPS (Activities)

1. See Resource #1 to learn how to copy to an archive disk and to obtain practice in copying a document to disk.

2. To learn how to file documents to an archive diskette and to obtain practice in document filing, see Resource #2.

3. See Resource #3 to learn how to retrieve documents from disk and to obtain practice in retrieving documents.

4. To learn how to delete documents and to obtain practice in deleting documents, see Resource #4.

5. See Resource #5 to learn how to complete multiple filing activities and to obtain practice in completing these activities.

6. To learn how to print an index and to obtain practice in printing an index, see Resource #6.

7. See Resource #7 to learn how to duplicate a disk and to practice duplicating a disk.

8. To review, see Resource #8.

9. Complete Resource 9A and 9B to check your understanding of the terminal performance objective and to measure your ability to manage files.

RESOURCES

1. Read pages 5-20 to 5-23 in FILING in your training manual completing the exercise as directed.

2. Read pages 5-24 to 5-26 in FILING - complete exercise as directed.

3. Read pages 5-27 to 5-29 and complete exercise as directed in FILING.

4. Read pages 5-30 to 5-32 and complete exercise as directed in FILING in your training manual.

5. Read pages 5-33 to 5-47 in FILING in your training manual; complete all exercises as directed.

6. Read pages 5-48 to 5-62 in FILING in your training manual; complete exercises as directed.

7. Read pages 5-63 to 5-67; complete exercise as directed in FILING in your training manual.

8. Read Information Sheet found on guide pages 5 to 8.

9. A. Product checklist on pages 9 and 10.
   B. Complete Criterion Exam 170.B.5.

DOCUMENT FILING

Document filing is a procedure for storing data for preservation and later use. Paper documents are stored in filing cabinets in manila folders while electronic documents are stored on system disks (hard disks) or archive (floppy disks).

The system disk on the Wang will hold 33.5 megabytes of data or approximately 10,000 pages; the archive diskette will store approximately 120 pages of text. Archive disks may be 5 1/4 inches or 8 inches. The disks you will be using on our system are 5 1/4 inches.

The system disk is permanently mounted in the master unit. All documents keyboarded on the Wang OIS 60 are automatically stored on the system disk. Documents may be removed from the system disk and stored permanently on an archive diskette.

Important parts of an archive diskette are the

(1) paper dust jacket,
(2) an identification label,
(3) recording slot,
(4) sealed black jacket,
(5) and the protective seal.

DISK CARE

Diskettes should be taken care of properly so that they will last a long time and so that data stored on the disk will not be damaged.

Follow these procedures to protect your archive diskette.

(1) Never write on the label with a pen after it has been applied to the disk.
(2) Do not let the adhesive of the label touch the recording slot.
(3) Return disks to paper dust jacket when not in use.
(4) Do not store near magnetic fields.
(5) Store diskettes in sturdy file folders in an upright position.
(6) Do not put more than one label on a disk.
(7) Store diskettes in an environment between 50 and 125 degrees Farenheit.
(8) Do not expose diskettes to excessive sunlight or heat.
(9) Do not place objects on top of disks.
(10) Do not touch the recording slot with you hands.
(11) Do not attempt to clean the disk with cleaning solvents.

(12) Do not mount damaged disks in the drive; it could damage the disk drive mechanism.
(13) Do not attach anything to diskettes such as a paper clip.
(14) Mail diskettes in special mailing devices or in strong cardboard.
(15) Do not place diskettes on the monitor or crt of a workstation.

FILING PROCEDURES

It is important to follow these filing procedures so that your documents are protected from damage and so they may easily be found or retrieved.

(1) Enter a logical name for each document.
(2) Enter comments in the Document Summary that identify the document for you.
(3) File documents on diskettes that are related.
(4) Print indexes for disks and for libraries.
(5) Delete unnecessary documents from the archive disk and the system disk.
(6) Duplicate diskettes.

PREPARING AN ARCHIVE DISKETTE

Preparing a disks consists of formatting that disk with tracks and sectors. Disks must be prepared or initialized before that may be used to store data.

Follow these steps to prepare a disk.

1. Select DOCUMENT FILING from the word processing menu; press EXECUTE.
2. Select PREPARE ARCHIVE DISKETTE; press EXECUTE.
3. Make certain write protect slot is uncovered; insert archive diskette in drive; close door; press EXECUTE.
4. Type X; press EXECUTE.
5. Make note of diskette ID.

DISMOUNTING AN ARCHIVE DISKETTE

It will be necessary for you to follow these steps when removing a disk from the drive. YOU SHOULD NEVER REMOVE A DISK WHEN THE RED LIGHT ON THE DISK DRIVE IS LIT.

1. Press COMMAND and Superscript/Subscript key (located next to Command key). Red light will go out.
2. Remove diskette.
3. Press CANCEL to clear prompt.

SINGLE FILING

When you wish to file a single document, follow the steps listed below.

1. Select DOCUMENT FILING; press EXECUTE.
2. Position acceptance block next to desired activity (copy, file, retrieve, delete); press EXECUTE.

   (a) Copy - A copy of the document is placed on the archive diskette. (The original copy still remains on the system disk.)
   (b) File - A copy of the document is placed on the archive diskette. The original copy is removed from the system disk.
   (c) Retrieve - A copy is taken from the archive disk and placed on the system disk.
   (d) Delete - Copy is deleted from archive disk or system disk.

3. Enter DOCUMENT ID; press EXECUTE.
4. Check document name; press EXECUTE.
5. Mount archive diskette; press EXECUTE until "In Progress" is displayed.

MULTIPLE FILING

Multiple filing allows you to file more than one document at a time. You can file up to 34 documents at a single time.

1. Select DOCUMENT FILING; press EXECUTE.
2. Position acceptance block next to desired activity; press RETURN. (COPY, FILE, RETRIEVE, DELETE)
3. Position acceptance block next to MULTIPLE; press EXECUTE.
4. Position cursor beneath first document to be filed; press INSERT. Continue pressing INSERT until all documents have been selected. Depress NEXT to move to next screen; depress DELETE to deselect a document; press EXECUTE.
5. Press EXECUTE; check Document ID and name; press EXECUTE.
6. Mount archive diskette, close door, and press EXECUTE.
7. Check diskette ID; continue pressing EXECUTE until "In Progress" is displayed.

PRINTING A DOCUMENT INDEX

You may wish to print a document index so that you will know what documents are stored on a particular disk.

1. Select SPECIAL PRINT FUNCTIONS from the word processing menu; press EXECUTE.
2. Select PRINT INDEX; press EXECUTE.
3. Select LIBRARY or ARCHIVE DISK; press RETURN; specify by Author, All, or By Operator; press RETURN; type name.
4. If printing an index for archive, mount disk; press EXECUTE; check ID, press EXECUTE.
5. Change Print Document Menu as needed; press EXECUTE. Most often you will want to delete this document as there is no need to save it on the system disk.
6. Press select on your printer to begin printing.

DUPLICATING A DISKETTE

It is good filing practice to make a copy of each archive diskette. The backup copy should be kept in a safe place so that all data stored on it is protected from damage or loss.

Follow these steps to make a copy of an archive diskette.

1. Select UTILITIES on the word processing menu.
2. Select DUPLICATE DISK; press EXECUTE.
3. Mount the original disk in the disk drive; press EXECUTE.
4. Dismount the original diskette; mount diskette to be duplicated; press EXECUTE.

SOURCE: WANG LABORATORIES

PERFORMANCE/PRODUCT CHECKLIST

Program: Secretarial Office Occupations

Task No: 170.B.5

Student's Name: _____ Date Of Attempt: _____

Evaluator's Name: _____ Evaluation Site: _____

Performance Attempt: 1 2 3 4

Terminal Performance Objective:

Given the needed supplies, equipment, and data, manage files on an OIS 60 Information Processing System.

To master this task you must score two out of two on a product checklist and score 19 out of 21 on a written exam.

Directions To The Student:

Before attempting this task for mastery, carefully review this checklist. You will be evaluated on the basis of this checklist. When you feel you are ready for evaluation, contact your instructor. You must complete your performance within 30 minutes and must score at least _____ out of _____ points or 100 % for mastery. Critical items are marked with an asterisk (*). These items must be satisfactorily completed.

Directions To The Evaluator:

The student will contact you when ready for the evaluation. The student must complete the performance within 30 minutes and must score _____ out of _____ points or 100 % and all items marked with an asterisk (*) must be satisfactorily completed.

PERFORMANCE/PRODUCT CHECKLIST

Name _____

	Yes	No
1. All training documents and documents you created have been filed to the archive disk.	___	___
2. A document index of the archive disk has been printed.	___	___

PROJECT SUMMARY SHEET - 170.B.5

This page is to be completed by your instructor.

1. Prepare an archive diskette. ____

2. Copy Resume of Ellen Scott to disk. ____

3. Copy AAA Travel Agency to disk. ____

4. File Resume of Ellen Scott to disk. ____

5. File Far East Tours to disk. ____

6. Retrieve Resume of Ellen Scott from the system disk and then copy to your archive disk. ____

7. Delete Combination Keys from the system disk. ____

8. Use multiple filing to copy filing documents to the archive disk. ____

   Christmas Sales Promotion
   First National Bank
   Central Electric Company

9. Use multiple filing to file documents to the archive disk. ____

   AAA Travel Agency
   Christmas Sales Promotion
   Central Electric Company
   First National Bank
   Field Support Personnel
   Review

10. Retrieve the following documents from the archive disk: ____

    AAA Travel Agency
    Christmas Sales Promotion
    Central Electric Company
    First National Bank
    Field Support Personnel
    Review

11. Print an index of your archive disk. ____

12. Print an index of all documents in your library. ____

13. Make a duplicate copy of your archive disk. ____

Project Summary Sheet (Continued)
170.B.5

Criterion Exam - Part I ___ ___ ___

Criterion Exam - Part II ___ ___ ___

Name _____ Date _____ Points _____

INFORMATION/WORD PROCESSING
SECRETARIAL OFFICE OCCUPATIONS
CRITERION EXAM

TASK 170.B.5

The purpose of this exam is to determine whether or not you have understood the information presented on document filing on a Wang OIS 60 Information Processing System.

Directions:

PART I

Write your answers on an answer sheet provided by your instructor. Select the answer that best completes or defines the statement. A minimum score of 90 percent is required.

PART II

Complete document filing as directed. A maximum time of 30 minutes is allowed to complete this portion of the exam. A score of 100 percent accuracy is required.

FILING - 170.B.5
POST TEST #1

PART I

DIRECTIONS: Write the letter that comes before the correct answer on an answer sheet. Do not write on this test. A minimum score of 90 percent is required.

---

1. Documents may be stored

   a. only on an archive disk.
   b. only on a system disk.
   c. on neither an archive disk or a system disk.
   d. on both the archive disk and the system disk.

2. When you store too much information on the system disk, it may

   a. erase all data stored on disk.
   b. wear out.
   c. not perform word processing functions efficiently.
   d. cause damage to the system disk.

3. When you no longer need documents that have been stored on disk, you can _____ used archive diskettes.

   a. not erase
   b. erase
   c. not reuse
   d. none of the above

4. When you copy a document from the system disk to an archive disk,

   a. you delete the document from the system disk and store it on the archive disk.
   b. you copy the document to the archive disk retaining a copy on the system disk.
   c. you delete the document from both the system disk and the archive disk.
   d. you copy the document to the archive disk deleting it from the system disk.

5. When you file to the archive diskette,

   a. you delete the document from the system disk and store it on the archive disk.
   b. you copy the document to the archive disk retaining a copy on the system disk.
   c. you delete the document from both the system disk and the archive disk.
   d. you copy the document to the system disk deleting it from the archive disk.

6. When you retrieve files from the archive diskette,

   a. you delete the document from the system disk and store it on the archive disk.
   b. you copy the document to the archive disk retaining a copy on the system disk.
   c. you copy the document from the archive disk to the system disk retaining a copy on the archive disk.
   d. you copy the document to the system disk deleting it from the archive disk.

7. When you prepare a diskette, you

   a. preserve data on the disk.
   b. reformat data on the disk.
   c. rearrange data on the disk.
   d. erase data stored on the disk.

8. Which of the following is a correct method for handling disks?

   a. Store in jackets in an upright position.
   b. Touch exposed areas with your hands.
   c. Write on disk labels only with ballpoint pens.
   d. Store near magnets.

9. When inserting a disk in the disk drive, it should be in the following position.

   a. recording slot up and facing the operator
   b. recording slot down and facing the operator
   c. recording slot up and inserted in drive first
   d. recording slot down and inserted in drive first

10. The sealed black jacket should

    a. be removed before using the disk.
    b. be removed after disk is full.
    c. not be removed until the disk is prepared.
    d. never be removed.

11. To unlock the disk drive door and dismount the diskette,

    a. press COMMAND and the Super/Subscript key.
    b. press COMMAND and the north cursor key.
    c. press COMMAND and the south cursor key.
    d. press COMMAND and both the north and south cursor keys.

12. "Delete from Library"

    a. removes documents permanently from the system disk
    b. removes documents permanently from the archive disk
    c. removes documents temporarily from the system disk
    d. removes documents temporarily from the archive disk

13. You can file up to - documents at one time by selecting multiple.

    a. 20
    b. 28
    c. 34
    d. 39

14. When performing multiple filing activities, the ——— key is used to indicate which documents you wish to file.

    a. Space bar
    b. Underscore
    c. Delete
    d. Insert

15. To position the cursor for multiple or range filing, you must touch the ——— key after you have returned and moved to "Single."

    a. Space bar
    b. Underscore
    c. Return
    d. Insert

16. The message "————————————" appears on the screen when multiple activities are completed.

    a. Filing Activities Complete
    b. End of Job
    c. Project Completed
    d. Batch Request Ended

17. You cannot print an index of

    a. all the documents on the system disk.
    b. all the documents in a library.
    c. all the documents on an archive disk.
    d. all the documents waiting to be printed.

18. The Duplicate disk option is located under the following menu pick.

    a. Utilities
    b. Document Filing
    c. Special Print Functions
    d. Glossary

19. When duplicating a disk,

    a. insert the original disk in the drive, close the door, and press CANCEL to begin duplication onto the system disk.
    b. insert the original disk in the drive, close the door, and press EXECUTE to begin duplication onto the system disk.
    c. insert the original disk in the drive, close the door, and press INSERT to begin duplication onto the system disk.
    d. insert the original disk in the drive, close the door, and press COMMAND to begin duplication onto the system disk.

20. After the archive disk has been copied to the system disk, remove the original disk from the drive, insert the blank disk and press —— to begin duplication.

    a. CANCEL
    b. COMMAND
    c. RETURN
    d. EXECUTE

21. Duplicating disks

    a. is expensive and should not be done.
    b. is a waste of time.
    c. is a good filing practice.
    d. is not necessary because of the reliability of the system disk.

POST TEST 170.B.5
DOCUMENT FILING

PART II

DIRECTIONS: Complete all activities that follow. These activities are designed to measure your understanding of document filing.

MULTIPLE FILING

1. Select File to Archive Diskette
2. Select Multiple Filing
3. Select all training documents assigned to you and any other documents you have created.
4. Press EXECUTE until (in progress) is displayed.

PRINT DOCUMENT INDEX

1. Select Archive Diskette.
2. Select All.
3. Print a copy of the document index.

HAND IN A COPY OF THE DOCUMENT INDEX.

NOTE: ALL YOUR DOCUMENTS HAVE BEEN REMOVED FROM THE SYSTEM DISK AND PLACED ON THE ARCHIVE DISK. THE NEXT TIME YOU NEED TO ACCESS A TRAINING DOCUMENT, YOU MUST RECALL IT FROM YOUR ARCHIVE DISK.

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COMPETENCY-BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

STUDENT LEARNING GUIDE

Produced By Jan Robinson Date 01-02-85

TASK: Format text on an OIS 60 Information Processing System.

PURPOSE: The OIS 60 Information Processing software enables the operator to format text quickly and efficiently. You can change line length, vertical line spacing, tabs, and center text automatically without rekeying any text.

INFORMATION PROCESSING

Program	Task	Est.Time	Prereq.
SOO	170.B.6	10 hours	170.B.1-170.B.5

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME _____ SOCIAL SECURITY NUMBER _____

LENGTH OF CONTRACT (NORMAL TIME IN HOURS) _____

2. TERMINAL PERFORMANCE OBJECTIVE

Given the needed data, supplies, and equipment, format text on an OIS 60 Information Processing System.

To master this task, you must score 28 out of 28 on a product checklist and score 22 out of 24 on a written exam.

2a. INTERMEDIATE OBJECTIVE(s)

1. Format text on an OIS 60 Information Processing System.

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____. I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

Student's Signature _____

Instructor's Signature (verifies competency) _____

INTERMEDIATE OBJECTIVE #1

Format text on an OIS 60 Information Processing System.

LEARNING STEPS (Activities)

1. To review procedures for centering text, setting tabs, see Resource #1.

2. To learn how to use the Wang Ruler and to obtain practice in the use of this ruler, see Resource #2.

3. See Resource #3 to learn how to revise an existing format line and to gain practice in making these revisions.

4. To learn how to use the horizontal scroll feature and to obtain practice in scrolling, see Resource #4.

5. To review the use of the format keys and gain additional practice in their use, see Resource #5.

6. See Resource #6 to learn the use of the decimal tab and to practice using this key.

7. See Resource #7 to learn how to create pages within a document and to obtain practice in creating these pages.

8. Complete Resource #8 A, B, and C to check your understanding of the terminal performance objective and to measure your ability to format text on an OIS 60 Information Processing System.

RESOURCES

1. Read FORMATTING TEXT in your training manual - pages 6-1 to 6-6; complete review exercise as directed.

2. Read and complete exercises as directed in FORMATTING TEXT on pages 6-7 to 6-12.

3. Read instructions and complete exercises in FORMATTING TEXT on pages 6-13 to 6-22.

4. Read FORMATTING TEXT in your training manual - pages 6-23 to 6-25; complete exercise as directed.

5. Read and complete exercises as instructed in FORMATTING TEXT in your training manual - pages 6-26 to 6-31.

6. Read instructions and complete exercises in FORMATTING TEXT in your training manual - pages 6-32 to 6-36.

7. Read and complete exercises as instructed in FORMATTING TEXT in your training manual - pages 6-37 to 6-40.

8. A. Read guide pages 4-6 to review.

   B. Product checklist on guide pages 7, 8, and 9.

   C. Complete Criterion Exam 170.B.6.

FORMATTING TEXT

Formatting text requires that you perform the following operations:

(1) Set line length and revise line length settings;
(2) Set vertical line spacing and revise line space settings;
(3) Set tabs and reset tabs for alignment of alpha and numerical data;
(4) Center lines;
(5) Use special keys for setting temporary margins;
(6) Paginate and repaginate text.

DOCUMENT FORMATTING DEVICES

Rulers that assist you in determining line length, tab settings, and page length are available for your use. These rulers genrally contain a scale for measuring number of characters per inch on a page either in 10 pitch, 12 pitch, or 15 pitch. Vertical spacing or page length may also be measured with these rulers.

Overlays are available also. These may be placed on a typed page or form to assist you with document formatting. Ask your instructor to demonstrate both of these devices.

LINE LENGTH, TABS, VERTICAL SPACING

The **Primary Format** line is set for you when you create a new document. This line may require revision. To revise this line, move the cursor directly below the Primary Format line

(1) Press Shift and FORMAT or FORMAT to move the cursor into the format line;
(2) Backspace and type the vertical spacing you desire;
  (a) 1 = Single
  (b) 2 = Double
  (c) 3 = Triple
  (d) W = Space and one half
  (e) H = Half spacing
  (f) Q = Quarter spacing
(3) Set the tabs desired by depressing the tab key - use the space bar to delete tabs by spacing over;
(4) Use the RETURN key when you have reached the desired line length.*
(5) Depress EXECUTE to move out of the format line.

*Left margin is set on the Print Document menu.

When you wish to change margins within a document, you use the FORMAT key to set an **Alternate Format** line. You might wish to do this if you have a long document that contains a table of statistics or a long quotation.

(1) Make certain that there is a least one blank line between the cursor and the primary format line;
(2) Depress FORMAT;
(3) Set vertical line spacing, tabs, and line length;
(4) Press EXECUTE.

You may decide to **delete an Alternate Format** line, To do this,

(1) Enter the format line by depressing SHIFT and FORMAT;
(2) Press Delete.

You may wish to set a **temporary indent for a left margin.** This would block all data at the first tab setting in the format line. To do this you would

(1) Press INDENT;
(2) Enter text to be typed;
(3) Press RETURN.

SCROLLING

Scrolling allows you to move beyond the 80 character normally viewed on the screen. If you were typing a long statistical report require the use of paper wider than 8 1/2 inches.

(1) Set the right margin in the format line at 100;
(2) Use the EAST CURSOR key to move the cursor to the right;
(3) Notice how the cursor moves past 80 to display data beyond that point.

CENTER KEY

To center lines, follow the steps listed below.

(1) Depress the CENTER key;
(2) Type the line to be centered;
(3) Depress the RETURN key.

The line is centered between the left margin you set on the Print Document menu and the line length set in the format line. The center graphic is the ◆ .

INFORMATION SHEET

RETURN KEY

The RETURN key allows you to create blank lines between paragraphs, to end short lines, to end format instructions such as centering, and to set the line length in the format line. A ◀ is the return graphic.

TAB KEY

When you wish to indent the first line of a paragraph or type columns of numbers, you use the tab key. A ▶ is the graphic for a tab.

INDENT KEY

The indent key is used when you wish to temporarily change the left margin. Notice that this paragraph is typed using the indent key. A → graphic indicates an indent has been used.

DECIMAL TAB

The DEC TAB key is used when you wish to align words at the right or numbers at the decimal point. This feature will save you a great deal of time when typing columns of numbers. A tab stop(s) must be set in the format line where you wish text to align. The graphic indicates you are using a decimal tab.

(1) Depress DEC TAB;
(2) Type numbers;
(3) Depress DEC TAB to move to next column*;
(4) Or depress RETURN for next line of data.

*You may use the DEC TAB, TAB, INDENT, or RETURN to end decimal alignment.

PAGE KEY

When you wish to start a new page, simply press the PAGE key. A special graphic ⊥ appears and the status line indicates that you are at position 1 - line 1 on a new page.

To delete a page, position the cursor under the page break graphic, depress DELETE, and EXECUTE.

Source: Wang Laboratories

PERFORMANCE/PRODUCT CHECKLIST

Program: SECRETARIAL OFFICE OCCUPATIONS

Task No: 170.B.6

Student's Name: _____ Date Of Attempt: _____

Evaluator's Name: _____ Evaluation Site: _____

Performance Attempt: 1 2 3 4

Terminal Performance Objective:

Given the needed data, supplies, and equipment, format text on an OIS 60 Information Processing System.

To master this task, you must score 28 out of 28 on a product checklist and score 22 out of 24 on a written exam.

Directions To The Student:

Before attempting this task for mastery, carefully review this checklist. You will be evaluated on the basis of this checklist. When you feel you are ready for evaluation, contact your instructor. You must complete your performance within 55 minutes and must score at least 28 out of 28 points or 100 % for mastery. Critical items are marked with an asterisk (*). These items must be satisfactorily completed.

Directions To The Evaluator:

The student will contact you when ready for the evaluation. The student must complete the performance within 55 minutes and must score 28 out of _____ points or 28 % and all items marked with an asterisk (*) must be satisfactorily completed.

PERFORMANCE/PRODUCT CHECKLIST

Part II

Yes	No	
____	____	Title typed in all caps and centered
____	____	Triple space follows main heading
____	____	Body of document - single spaced; double spaced between paragraphs
____	____	Line length - 60
____	____	Tab stop at 5
____	____	Left and right margins even
____	____	All errors corrected
____	____	Document summary printed
____	____	Hard copy printed

Part III

Yes	No	
____	____	Title typed in all caps and centered
____	____	Triple space followed main heading
____	____	Vertical spacing - space and a half
____	____	Line length - 70
____	____	Tab stop at 10
____	____	Paragraph #2 block indented 10 spaces (use indent key)
____	____	Left and right margins even
____	____	All errors corrected
____	____	Document summary printed
____	____	Hard copy printed

PERFORMANCE/PRODUCT CHECKLIST

Part IV

Yes	No	
_____	_____	Title capitalized and centered
_____	_____	Double spaced columnar data
_____	_____	Triple spaced after main heading
_____	_____	10 spaces left between columns
_____	_____	Left and right margins even
_____	_____	Decimals aligned
_____	_____	Errors corrected
_____	_____	Document summary printed
_____	_____	Hard copy printed

PROJECT SUMMARY SHEET
170.B.6

DIRECTIONS: This page is to be completed by your instructor.

Training Manual - Formatting Text

_____ Resume for Ellen Scott

_____ The Character Keys

_____ Decimal Tab Alignment

_____ Wang Ruler

_____ Format Keys

_____ Create Pages

_____ Format lines

_____ Centering Text

_____ Music Lessons

Criterion Exam 170.B.6

_____ _____ _____ Part I

_____ _____ _____ Part II

_____ _____ _____ Part III

_____ _____ _____ Part IV

Name _____ Date _____

Points _____

INFORMATION/WORD PROCESSING
SECRETARIAL OFFICE OCCUPATIONS
CRITERION EXAM

TASK 170.B.6

The purpose of this exam is to determine whether or not you have understood the information presented on document formatting on a Wang OIS 60 Information Processing System.

Directions:

PART I

Write your answers in the space provided to the left of the question. Select the answer that best completes or defines the statement. A minimum score of 90 percent is required.

PART II

Keyboard the document as directed. Follow all instructions given for formatting the text. Correct any errors made. A maximum time of 20 minutes will be allowed to complete this part of the examination.

PART III

Make changes indicated. A maximum time of five minutes will be allowed to make formatting changes indicated.

PART IV

Keyboard columnar text as directed. Correct any errors made while keying in text. Follow all instructions given. A maximum time of 30 minutes is allowed to complete this portion of the test.

PART I

FORMATTING TEXT - 170.B. 6
POST TEST #1

DIRECTIONS: Write your answer on the answer sheet provided by your instructor. Do not write on this test. Select the letter that comes before the answer that best completes or defines the statement.

---

1. A document formatting ruler provides you with a two-sided ruler displaying the following scale(s).

   a. horizontal scale
   b. vertical scale
   c. both a and b
   d. none of the above

2. The vertical centering scale on the Wang ruler has ——— lines per inch.

   a. 6
   b. 8
   c. both a and b
   d. none of the above

3. The horizontal centering scale on the Wang document formatting ruler has a — pitch scale(s).

   a. 10
   b. 12
   c. 15
   d. all of the above

4. The horizontal centering scale should be used to set the ——— on the Print Document menu.

   a. page length
   b. top margin
   c. right margin
   d. left margin

5. The vertical centering scale is used to determine the correct ——— setting for the Print Document menu.

   a. page length
   b. top margin
   c. right margin
   d. left margin

6. The number of lines to be entered under page length on the Print Document index for a sheet of paper 8 1/2 x 13 would be

   a. 66.
   b. 90.
   c. 78.
   d. none of the above

7. The number of lines to be entered under page length on the Print Document index for a business-size envelope (No. 10) would be

   a. 30.
   b. 25.
   c. 29.
   d. none of the above

8. To move into the format line from the fifth line below the format line, you press

   a. SHIFT and COMMAND.
   b. COMMAND and FORMAT.
   c. SHIFT and FORMAT.
   d. FORMAT and PAGE.

9. When the cursor is positioned directly under the first character that follows the format line, press just the ——— key to enter the format line for revisions.

   a. FORMAT
   b. PAGE
   c. SHIFT
   d. COMMAND

10. If the cursor is not positioned beneath the first character following the format line when you press FORMAT,

   a. the Primary Format line will be changed.
   b. a new Alternate Format line will be created.
   c. the Format line preceding the character will be deleted.
   d. none of the above

11. The following options are available when setting vertical spacing.

   a. single spacing, double spacing, triple spacing
   b. half spacing, quarter spacing
   c. one and one-half spacing
   d. all of the above

12. Tabs may be deleted while in the format line by

    a. moving over with the EAST cursor key.
    b. moving over with the WEST cursor key.
    c. deleting with the DELETE key.
    d. spacing over with the space bar.

13. When using a 12-pitch print wheel and a line length of 72 to print out on a sheet of paper 8 1/2 x 11 inches, you would set the left margin at —— on the Print Document menu.

    a. 12
    b. 15
    c. 7
    d. none of the above

14. Document may be created up to —— characters wide on the Wang OIS 60 word processor.

    a. 160
    b. 150
    c. 140
    d. none of the above

15. Scrolling allows you to

    a. see text that extends beyond the normal 80 characters displayed on the screen.
    b. write directly on the screen with a special device called a mouse.
    c. touch the screen with your finger when editing changes are required.
    d. none of the above

16. The CENTER key allows you to

    a. center text automatically.
    b. center text horizontally on the screen.
    c. both a and b.
    d. none of the above.
    e. all of the above.

17. The RETURN key allows you to

    a. create blank lines between paragraphs.
    b. end paragraphs and short lines.
    c. end a format instruction and set the line length.
    d. all of the above
    e. both a and b

18. The TAB key allows you to

a. indent the first line of a paragraph.
b. type columns of text to be aligned at the left.
c. all of the above
d. none of the above

19. The INDENT key is used to

a. indent the first line of a paragraph.
b. type columns of text to be aligned at the left.
c. create a temporary left margin.
d. none of the above

20. The DEC TAB key is used to

a. align text at the left.
b. align text at the right .
c. align text at the decimal.
d. both a and c
e. both b and c

21. A document to be printed on a sheet of paper 8 1/2 by 11 with a one-inch top and bottom margin would most usually contain ___ lines of text.

a. 50
b. 66
c. 54
d. none of the above

22. Blank lines and page numbers located at the top of a document are called

a. headers.
b. footers.
c. toppers.
d. none of the above

23. To create a new page as you are keyboarding,

a. press PREV.
b. press NEXT.
c. press PAGE.
d. press SHIFT + PAGE.

24. To delete a page break graphic,

a. position the cursor beneath the graphic and depress PAGE.
b. position the cursor beneath the graphic, press DELETE and then EXECUTE.
c. position the cursor beneath the graphic and space over with the space bar.
d. all of the above

FORMATTING
POST TEST #1

PART II

DIRECTIONS: Type the article that follows. Use single spacing and a 60 space line. Set a tab stop at five. Correct any errors you make while keyboarding this article. Print the document summary and a hard copy.

COMPUTER/PHONE LINKS PC'S

The Communications CoSystem from Cygnet Technologies, Inc., Sunnyvale, CA, links the personal computer and telephone in a desktop system for use by virtually any business person or professional. A telecommunications microcomputer working in tandem with the IBM Personal Computer or compatibles, it automates the communications tasks that are needed for local area networking and for geographically dispersed locations.

Users can communicate via their personal computers over standard telephone lines. Its advanced electronic mail system provides point-to-point communications between CoSystem-equipped PC's through standard telephone lines. The user can interrupt an application on the PC, send messages, and then resume processing. Messages can be sent and received while the telephone is in use, and incoming messages are displayed on the screen and stored in memory or on a diskette. A red indicator light flashes when a message has not been received.

Other features include the ability to automatically send messages simultaneously to a number of different recipients on a distribution list; notification of whether the message was received and filed at the intended destination point; and a sophisticated CRC-16 error-checking scheme that allows transmission of virtually error-free data, including programming code requiring 100 percent accuracy.

Source: Unknown

PART III

DIRECTIONS: Change the line length to 70, the vertical spacing to space and a half, and paragraph indentation to 10. Block indent Paragraph 2. Print the document summary and a hard copy.

PART IV

DIRECTIONS: Type the columnar data that follows. Center the title; use double spacing. Leave 10 spaces between columns. Align decimals. Correct any errors you make while keyboarding. Print the document summary and a hard copy.

SOFTWARE BEST SELLERS

Wordstar	$495.00	Apple, CP/M, MSDOS
Multiplan	250.00	Apple, CP/M, MSDOS
SuperCalc III	395.00	Apple, CP/M, MSDOS
Lotus 1-2-3	495.00	MSDOS, TI
PFS:Write	125.00	MSDOS, TI
Symphony	695.00	MSDOS
SuperCalc II	295.00	Apple, CP/M, MSDOS
PFS:File	125.00	Apple, MSDOS, CP/M
PFS:Report	125.00	Apple, MSDOS, TI
SuperCalc	295.00	Apple, MSDOS, TeleVideo

File all documents created and editing for Guide 170.B.6 and for this exam to your diskette.

Source Unknown

LAKE
COUNTY
AREA
VOCATIONAL
CENTER

COMPETENCY-BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

STUDENT LEARNING GUIDE

Produced By Jan Robinson Date 01-03-85

TASK: Edit text on the Wang OIS 60 Information Processing System

PURPOSE: One of the capabilities of most word processings software programs is that of text editing or manipulating previously keyboarded data. Basic editing on the Wang OIS 60 Information Processing System involves the functions of inserting, deleting, replacing text, and automatic pagination. In this guide you will learn how to perform these operations.

INFORMATION PROCESSING

Program	Task	Est.Time	Prereq.
SOO	170.B.7	10 hours	170.B.1-170.B.6

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME _____ SOCIAL SECURITY NUMBER _____

LENGTH OF CONTRACT (NORMAL TIME IN HOURS) _____

2. TERMINAL PERFORMANCE OBJECTIVE

Given the needed data, supplies, and equipment, edit text on the Wang OIS 60 Information Processing System.

To master this task, you must score 17 out of 17 on a product checklist and score 13 out of 15 on a written exam.

2a. INTERMEDIATE OBJECTIVE(s)

1. Insert, delete, and strikeover data on a Wang OIS 60 Information Processing System.

2. Edit text on the Wang OIS 60 Information Processing System.

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____. I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

Student's Signature _____

Instructor's Signature (verifies competency) _____

INTERMEDIATE OBJECTIVE #1

Insert, delete, and strikeover data on the Wang OIS 60 Information Processing System.

LEARNING STEPS (Activities)

1. See Resource #1 to edit text using strikeover.
2. To highlight and dehighlight text, see Resource #2.
3. To review editing features available on the Wang OIS 60, see Resource #3.
4. To improve techniques for text editing using strikeover, see Resource #4.
5. See Resource #5 to delete text on the Wang OIS 60.
6. To insert text on the Wang OIS 60, see Resource #6.
7. Complete Resource #7 to learn how to correct errors while inserting and to obtain skill in the use of this technique.
8. Proceed to Intermediate Objective #2.

RESOURCES

1. Read pages 7-1 to 7-6 in your training manual - BASIC TEXT EDITING. Complete introductory exercise as instructed.
2. Read instructions and complete exercises as directed in your training manual - BASIC TEXT EDITING.
3. Read pages 7-14 to 7-15 in your training manual - BASIC TEXT EDITING.
4. Complete exercise on pages 7-16 to 7-18 in your training manual - BASIC TEXT EDITING.
5. Complete exercise as instructed on pages 7-19 to 7-21 in BASIC TEXT EDITING.
6. Read page 7-22 and complete exercise as directed on page 7-23 to 7-24 in your training manual - BASIC TEXT EDITING.
7. Read page 7-25 to 7-28 and complete exercise as directed - training manual - BASIC TEXT EDITING.
8. Guide - page 4.

INTERMEDIATE OBJECTIVE #2

Edit text on the Wang OIS 60 Information Processing System.

LEARNING STEPS (Activities)

1. To replace one word with another on the Wang OIS 60 Information Processing System, see Resource #1.

2. To adjust page length on a document on the Wang OIS 60, see Resource #2.

3. To review procedures for basic text editing on the Wang, see Resource #3.

4. To review basic text editing techniques, see Resource #4.

5. Complete Resource #5 A. and B. to check your understanding of the terminal performance objective and to measure your ability to edit documents on a Wang OIS 60 Information Processing System.

RESOURCES

1. Read page 7-29 to 7-31 in your training manual - BASIC TEXT EDITING. Complete exercises as directed on pages 7-31 to 7-38 in your training manual - BASIC TEXT EDITING.

2. Read page 7-39 in your training manual - BASIC TEXT EDITING. Complete exercise as directed on page 7-40 to 7-42.

3. Read Information Sheet #1 on guide pages 5 and 6.

4. Complete skill building exercise on page 7-46-7-47 of your training manual - BASIC TEXT EDITING.

5. A. Read Product/Performance checklist on pages 7 and 8 of this guide.

   B. Complete Criterion Exam 170.B.7.

BASIC TEXT EDITING
170.B.7
INFORMATION SHEET #1

To edit text on the WANG OIS 60 Information Processing System, it is necessary to highlight the text you wish to change. This may be done in many ways. To begin the editing function, depress any of the four editing keys listed below.

Editing Keys Delete, Copy, Move, Rplc

HIGHLIGHTING

Any of the following keys may be used to highlight text. Text will be highlighted to the next occurrence of the character depressed.

Space Bar	Indent Key	Page	Center
Dec Tab	Return	Tab	South Cursor Key
Next Screen	Go To		East Cursor Key

DEHIGHLIGHTING

The BACKSPACE KEY, PREV SCRN, EAST CURSOR KEY, AND NORTH CURSOR KEY can be used to dehighlight text.

DELETE

To delete text, complete the following steps.

1. Position the cursor under the first character to be deleted.
2. Press DELETE.
3. Highlight text.
4. Press EXECUTE.

INSERT

To insert text to an already typed document, follow the steps listed below.

1. Position cursor under first character to follow insert.
2. Press INSERT.
3. Type text to be added.
4. Press EXECUTE.

(Strikeover must be used to correct errors made while inserting.)

REPLACE

Replace is used when you want to delete one character string of text and replace it with another. For instance, a vice president in your company has retired and has been replaced. You wish to replace the name of the old vice president with the name of the new vice president in a document.

1. Position cursor under first character to be replaced.
2. Press RPLC.
3. Highlight text to be replaced.
4. Press EXECUTE.
5. Type new text.
6. Press EXECUTE.

GLOBAL REPLACE

When you want to replace a word that might occur several times in the same document with another word. You would use GLOBAL REPLACE.

1. Position cursor under first character to be replaced.
2. Hold down SHIFT and press RPLC.
3. Highlight text to be replaced.
4. Press EXECUTE.
5. Type new text.
6. Press EXECUTE.
7. Hold down SHIFT and press RPLC again.

AUTOMATIC PAGINATION

Automatic pagination will automatically end pages at a preset number of lines.

1. Go to the top of page 1.
2. Press COMMAND and then PAGE.
3. Answer the prompt with the number of lines you want on each page - usually 54.
4. Press EXECUTE.
5. The system will highlight the text it has determined should be on page one. You can either lengthen or shorten the page by positioning the cursor under the first character of the line to appear on the next page. Press EXECUTE.

Source: Wang Laboratories

PERFORMANCE/PRODUCT CHECKLIST

Program: SECRETARIAL OFFICE OCCUPATIONS

Task No: 170.B.6

Student's Name: _____ Date Of Attempt: _____

Evaluator's Name: _____ Evaluation Site: _____

Performance Attempt: 1 2 3 4

Terminal Performance Objective:

Given the needed data, supplies, and equipment, edit text on the Wang OIS 60 Information Processing System.

To master this task, you must score 17 out of 17 on a product checklist and score 13 out of 15 on a written exam.

Directions To The Student:

Before attempting this task for mastery, carefully review this checklist. You will be evaluated on the basis of this checklist. When you feel you are ready for evaluation, contact your instructor. You must complete your performance within 60 minutes and must score at least 17 out of 17 points or 100 % for mastery. Critical items are marked with an asterisk (*). These items must be satisfactorily completed.

Directions To The Evaluator:

The student will contact you when ready for the evaluation. The student must complete the performance within 60 minutes and must score 17 out of 17 points or 100 % and all items marked with an asterisk (*) must be satisfactorily completed.

PERFORMANCE/PRODUCT CHECKLIST

170.B.7

YES	NO	
		Title centered in all caps
		Secondary heading centered
		Double spaced between main and secondary heading
		Triple spaced after secondary heading
		Body of document double spaced except where indicated
		Line length - 70
		Paragraphs indented 5 spaces
		Minimum of 1-inch top and bottom margin
		Left and right margin even

Editing changes made as indicated below

		Paragraphs 4, 5, 6 single spaced and block indented
		Paragraph beginning "The Overcontroller" moved as indicated
		"in" removed
		Paragraph beginning "But sometimes, say Lopez," deleted
		Paragraph beginning "A typical corporate executive:" inserted as indicated
		All keyboarding errors corrected
		Document summaries printed
		Hard copies printed

PROJECT SUMMARY SHEET
170.B.7

Directions: This page is to be completed by your instructor.

Training Manual

_____ Resume for Ellen Scott

_____ Market Report

_____ Page Length

_____ The Bells

_____ Typing Letters & Memos

_____ Typing

Criterion Exam 170.B.6

_____ _____ _____ PART I

_____ _____ _____ PART II

Name _____ Date _____
Points _____

INFORMATION/WORD PROCESSING
SECRETARIAL OFFICE OCCUPATIONS
CRITERION EXAM

TASK 170.B.7

The purpose of this exam is to determine whether or not you have understood the information presented on editing text on a Wang OIS 60 Information Processing System.

Directions:

PART I

Circle the letter T if the answer is true; if the answer is false, circle the letter F. A minimum score of 90 percent is required.

PART II

Keyboard the document as directed. Follow all instructions given for formatting the text. Correct any errors made. Print a hard copy and a document summary. A maximum time of 50 minutes will be allowed to complete this part of the examination.

PART III

Make editing changes indicated. Print a document summary and a hard copy. A maximum time of 10 minutes will be allowed to make needed changes.

DIRECTIONS: Choose the best answers. Write your answer on the blank space to the left of the question.

BASIC TEXT EDITING
170.B.7

_____ 1. To highlight text to the end of a paragraph when you are at the first character in the paragraph, press

1. tab.
2. space.
3. paragraph.
4. return.

_____ 2. To dehighlight text, press

1. dehighlight key.
2. the return key.
3. backspace key.
4. none of the above.

_____ 3. The copy key is used when you what to

1. move text.
2. make an exact duplicate of text on the screen.
3. delete text.
4. none of the above.

_____ 4. The move key is used when you what to

1. duplicate text and leave the original text in tact.
2. delete the original text and position it at another place in the document.
3. delete a specific amount of text.
4. none of the above.

_____ 5. If you decide that you do not want to complete an editing function that has been started, press

1. EXECUTE
2. COMMAND
3. DELETE
4. CANCEL

_____ 6. Strikeover should be used when you want to

1. replace one word with another of the same length
2. replace one word with a longer word.
3. delete a large amount of text.
4. insert a large amount of text.

_____ 7. Most screen graphics may be deleted using

1. the delete key.
2. the strikeover method.
3. both 1 and 2.
4. none of the above.

_____ 8. To add text to a previously typed document, it is best to use the ———————— key.

1. INSERT
2. DELETE
3. CANCEL
4. COMMAND

_____ 9. To remove an indent graphic, position the cursor under the graphic, depress ———————— and then execute.

1. INSERT
2. DELETE
3. CANCEL
4. RPLC

_____ 10. When you want to replace a number of characters with a number of unequal characters, it is best to use the ———————— key.

1. INSERT
2. RPLC
3. CANCEL
4. COMMAND

_____ 11. _____ automatically replaces every instance of a defined sequence of characters with another defined sequences of characters.

1. GLOBAL SRCH
2. SRCH
3. GLOBAL RPLC
4. RPLC

_____ 12. To set the length of a page at 54 lines, press PAGE and type

1. 66 then 54.
2. 54 then 66.
3. 66.
4. 54.

_____ 13. To automatically paginate a document, press _____ then type the number of lines per page.

1. SHIFT and PAGE.
2. SHIFT and COMMAND.
3. PAGE and SHIFT.
4. COMMAND and PAGE.

_____ 14. If the last line of highlighted text indicated a page break during automatic pagination is not at a logical point, press the _____ key to choose a logical page break.

1. North Cursor Key
2. South Cursor Key
3. Either of the above whichever is appropriate
4. None of the above

_____ 15. Choose the key from those listed below which will move the cursor forward in one stroke to the desired position. You are at the beginning of the first word in a paragraph and wish to highlight text to the space at the end of that word.

1. SPACE BAR
2. RETURN KEY
3. PERIOD
4. NONE OF THE ABOVE

Name _____

PART II Start time _____ Stop time _____

INSTRUCTIONS

Key in the following exercise. Print the document summary and a hard copy of this document. After completion, proofread your document and complete the corrections as indicated on the following page.

FORMAT REQUIREMENTS:

Vertical Line Spacing = 2, Tab 5, Line length 65

IRRATIONALITY AT THE TOP

Executives often don't rule by reason

Who are the irrational executives? Adolf Hitler is a good example, says psychoanalyst Abraham Zeleznik of Harvard Business School. "The charismatic leader is the exact opposite of the 'rational' manager," he continues. "Too much emotionality comes into play. Under the sway of the charismatic effect, both bosses and their subordinates can lose their independent capacity for making judgments. People identify with charismatic leaders, which results in a great deal of cohesion and a sense of solidarity."

Harry Levinson, head of the Levinson Institute, an association of clinical psychologists and physicians in Belmont, Massachusetts, says the irrational executive chooses his occupational role to fit his unconscious psychological needs. He describes a few widely prevalent types:

The Perfectionist relentlessly drives subordinates to support his impossibly lofty goals while treating them with condescension and

contempt. The result is a demoralized staff that may burn out because of his obsession

The Entrepreneur can't lead the organization he creates, nor can he allow others to rise as possible successors to make creative contributions. He wants to invent new products, yet unconsciously fears being outshone. Apple computer points out Levinson, foresaw such a predicament and hired an outside executive to manage the company. This freed the entrepreneurs from their anxieties and allowed them to be imaginative.

The Overcontroller invites ideas, yet ignores them. A common order is "Don't discuss it, just do it." He takes jobs that require compulsive, meticulous work and easily climbs the corporate ladder. But his domineering attitude eventually alienates his staff.

According to psychiatrist Philip Mechanick, of the University of Pennsylvania School of Medicine, the irrational executive may develop inappropriate relationships with his coworkers. "One executive in the throes of a major business decision became neurotically needful of his partner's approval," he notes. "Instead of dealing with the situation in objective, realistic terms, he acted to please his associate, which was grossly at variance with the interests of the enterprise."

An irrational executive "loses his ability to look at people in terms of their real roles and regards an individual subordinate or a small group of them in terms of what he needs emotionally," Mechanick explains. "No executive is entitled to expect his subordinates to look after him. Nixon apparently depended on a couple of inside-track cronies, and he followed their advice blindly. In in the end, he was done in."

What can corporations do about irrational executives? Since many of the culprits prove unable to change, Felix Lopez, author of The Making of a Manager, recommends a variety of solutions, varying from counseling to changing jobs. "One of my clients was a highly competent engineer who, when moved up to chief of engineering, began trying to do everything himself. He refused to delegate tasks, incurred the hatred of his staff and criticized top management." For this particular executive, a reassignment seemed the only sensible answer.

But sometimes, says Lopez, "trying to reform a person poorly suited to an executive position is futile." Sadly, "only fifteen to twenty percent of executives are truly effective. A better way to head off trouble would be to identify potentially gifted executives early and nurture them," thus creating a larger supply of competent people in top management. IBM and General Electric, to give two examples, already have a policy of bringing promising people along.

But sometimes, says Lopez, "trying to reform a person poorly suited to an executive position is futile." Sadly, "only fifteen to twenty percent of executives are truly effective. A better way to head off trouble would be to identify potentially gifted executives early and nurture them," thus creating a larger supply of competent people in top management. IBM and General Electric, to give two examples, already have a policy of bringing promising people along.

Douglas LaBier, a psychoanalyst at the Project on Technology, Work and Character in Washington, D. C., suggests that the focus should be on the organization as well as on the individual executive.

"Companies may support and develop irrational attitudes. People with certain emotional disturbances - grandiosity, narcissism or

sadomasochism, for example - can become successful executives. While considered pathologically sick, they function normally because their symptoms are adaptive, reinforced or actually required by their job and its demands."

Changing attitudes toward success may soon make irrational bosses a thing of the past, however. "Today, young executives want personal fulfillment and good health." LaBier observes. "They are willing to be on a slower track. For them, a sense of accomplishment is more important than money."

SOURCE: Unknown

PART III Start time _____ (10) Stop time _____

INSTRUCTIONS

Execute the following indicated revisions. Print a document summary and a hard copy after all revisions have been made.

FORMAT REQUIREMENTS:

Vertical Line Spacing = 2, Tab 5, Line length 70, Top and bottom margins - minimum of 1 inch

IRRATIONALITY AT THE TOP

Executives often don't rule by reason

Triple space

Who are the irrational executives? Adolf Hitler is a good example, says psychoanalyst Abraham Zeleznik of Harvard Business School. "The charismatic leader is the exact opposite of the 'rational' manager," he continues. "Too much emotionality comes into play. Under the sway of the charismatic effect, both bosses and their subordinates can lose their independent capacity for making judgments. People identify with charismatic leaders, which results in a great deal of cohesion and a sense of solidarity."

Harry Levinson, head of the Levinson Institute, an association of clinical psychologists and physicians in Belmont, Massachusetts, says the irrational executive chooses his occupational role to fit his unconscious psychological needs. He describes a few widely prevalent types:

Single space

The Perfectionist relentlessly drives subordinates to support his impossibly lofty goals while treating them with condescension and

Block indent

contempt. The result is a demoralized staff that may burn out because of his obsession

The Entrepreneur can't lead the organization he creates, nor can he allow others to rise as possible successors to make creative contributions. He wants to invent new products, yet unconsciously fears being outshone. Apple computer points out Levinson, foresaw such a predicament and hired an outside executive to manage the company. This freed the entrepreneurs from their anxieties and allowed them to be imaginative.

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delete

But sometimes, says Lopez, "trying to reform a person poorly suited to an executive position is futile." Sadly, "only fifteen to twenty percent of executives are truly effective. A better way to head off trouble would be to identify potentially gifted executives early and nurture them," thus creating a larger supply of competent people in top management. IBM and General Electric, to give two examples, already have a policy of bringing promising people along.

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Douglas LaBier, a psychoanalyst at the Project on Technology, Work and Character in Washington, D. C., suggests that the focus should be on the organization as well as on the individual executive.

"Companies may support and develop irrational attitudes. People with certain emotional disturbances - grandiosity, narcissism or

sadomasochism, for example - can become successful executives. While considered pathologically sick, they function normally because their symptoms are adaptive, reinforced or actually required by their job and its demands."

Changing attitudes toward success may soon make irrational bosses a thing of the past, however. "Today, young executives want personal fulfillment and good health." LaBier observes. "They are willing to be on a slower track. For them, a sense of accomplishment is more important than money."

Insert at beginning of document

A typical corporate executive: as he rational, logical, sensible, dependable? An ideal leader, decision maker and manager? Not necessarily writes psychoanalyst Manfred Kets de Vries in the Irrational Executive, an anthology published in May by International Universities Press. When stakes and salaries are high, bosses behave less like stereotypical leaders and more like human animals. Kets de Vries and others are now scrutinizing aberrant executives behavior with an eye to finding a way to tame it.

Directions: This is the final printout of your test. Check your copy against the copy that follows. Make any needed changes in your copy before handing it in. Margins and page length may vary slightly. File your final copy to diskette.

IRRATIONALITY AT THE TOP

Executives often don't rule by reason

A typical corporate executive: Is he rational, logical, sensible, dependable? An ideal leader, decision maker and manager? Not necessarily, writes psychoanalyst Manfred Kets de Vries in The Irrational Executive, an anthology published in May by International Universities Press. When stakes and salaries are high, bosses behave less like sterotypical leaders and more like human animals. Kets de Vries and others are now scrutinizing aberrant executive behavior with an eye to finding a way to tame it.

Who are the irrational executives? Adolf Hitler is a good example, says psychoanalyst Abraham Zeleznik of Harvard Business School. "The charismatic leader is the exact opposite of the 'rational' manager," he continues. "Too much emotionality comes into play. Under the sway of the charismatic effect, both bosses and their subordinates can lose their independent capacity for making judgments.

People identify with charismatic leaders, which results in a great deal of cohesion and a sense of solidarity."

Harry Levinson, head of the Levinson Institute, an association of clinical psychologists and physicians in Belmont, Massachusetts, says the irrational executive chooses his occupational role to fit his unconscious psychological needs. He describes a few widely prevalent types:

> The Perfectionist relentlessly drives subordinates to support his impossibly lofty goals while treating them with condescension and contempt. The result is a demoralized staff that may burn out because of his obsession
>
> The Overcontroller invites ideas, yet ignores them. A common order is "Don't discuss it, just do it." He takes jobs that require compulsive, meticulous work and easily climbs the corporate ladder. But his domineering attitude eventually alienates his staff.
>
> The Entrepreneur can't lead the organization he creates, nor can he allow others to rise as possible successors to make creative contributions. He wants to invent new products, yet unconsciously fears being outshone. Apple computer points out Levinson, foresaw such a predicament and hired an outside executive to manage the company. This freed the entrepreneurs from their anxieties and allowed them to be imaginative.

According to psychiatrist Philip Mechanick, of the University of Pennsylvania School of Medicine, the irrational executive may develop inappropriate relationships with his coworkers. "One executive in the throes of a major business decision became neurotically needful of his partner's approval," he notes. "Instead of dealing with the situation in objective, realistic terms, he acted to please his associate, which was grossly at variance with the interests of the enterprise."

An irrational executive "loses his ability to look at people in terms of their real roles and regards an individual subordinate or a small group of them in terms of what he needs emotionally," Mechanick

explains. "No executive is entitled to expect his subordinates to look after him. Nixon apparently depended on a couple of inside-track cronies, and he followed their advice blindly. In the end, he was done in."

What can corporations do about irrational executives? Since many of the culprits prove unable to change, Felix Lopez, author of The Making of a Manager, recommends a variety of solutions, varying from counseling to changing jobs. "One of my clients was a highly competent engineer who, when moved up to chief of engineering, began trying to do everything himself. He refused to delegate tasks, incurred the hatred of his staff and criticized top management." For this particular executive, a reassignment seemed the only sensible answer.

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COMPETENCY-BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

STUDENT LEARNING GUIDE

Produced By Jan Robinson Date 01-05-85

TASK: Copy and move text on a Wang OIS 60 Information Processing System

PURPOSE: When making text revisions, it may be necessary to move a paragraph from one place within a document to another place. If two paragraphs or lists of data are almost identical, you might find it easier to make a copy of the paragraph that has been keyboarded and then make the needed changes. The Wang allows you to perform these functions with just a few simple keystrokes.

INFORMATION PROCESSING

Program	Task	Est.Time	Prereq.
SOO	170.B.8	6 hours	170.B.1-170.B.7

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME _____ SOCIAL SECURITY NUMBER _____

LENGTH OF CONTRACT (NORMAL TIME IN HOURS) _____

2. TERMINAL PERFORMANCE OBJECTIVE

Given the needed information, supplies, and equipment, copy and move text on the Wang OIS 60 Information System.

To measure your ability to perform this task, you must answer correctly 9 out of 10 questions on a written exam and score 22 out of 22 on a product checklist.

2a. INTERMEDIATE OBJECTIVE(s)

1. Copy and move text on a Wang OIS 60 Information Processing System.

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____. I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

Student's Signature _____

Instructor's Signature (verifies competency) _____

INTERMEDIATE OBJECTIVE #1

Copy and move text on the Wang OIS 60 Information Processing System.

LEARNING STEPS (Activities)

1. Read Resource #1 to learn how and when to copy and move text.

2. To move text on the Wang OIS 60, see Resource #2.

3. See Resource #3 to copy and move text within a document.

4. Complete Resource #4 to learn how to move and copy text from one document to another document.

5. To copy and move text to another document, see Resource #5.

6. To review procedures for copying and moving text, see Resource #6.

7. To gain additional skill in copying and moving data, see Resource #7.

8. To measure your understanding of the terminal performance objective and your ability to copy and move text, see Resource 8A and 8B.

RESOURCES

1. Page 8-11 to 8-13 in your training manual - COPYING AND MOVING TEXT.

2. Read instructions and complete exercise on pages 8-3 to 8-10 in your training manual - COPYING AND MOVING TEXT.

3. Read instructions and complete exercises on pages 8-14 to 8-23 in COPYING AND MOVING TEXT.

4. Read page 8-24 in your training manual - COPYING AND MOVING TEXT.

5. Complete exercises as directed on pages 8-25 to 8-26 in COPYING AND MOVING TEXT.

6. Read pages 4 and 5 in your guide - Information Sheet #1 - 170.B.8.

7. Complete exercises as directed on pages 8-29 to 8-45 in COPYING AND MOVING TEXT.

8. A. Read pages 6 and 7 in this guide - Product/Performance Checklist 170.B.8.

   B. Complete Criterion Exam 170.B.8.

COPYING AND MOVING TEXT
INFORMATION SHEET #1
170.B.8

COPY

Copy allows the operator to make an exact copy of a word, sentence, paragraph, or any segment of text and position that exact copy anywhere he/she chooses within a document. The original word, sentence, or paragraph remains intact. To make an exact copy of text, follow these steps:

1. Position cursor under first character to be copied.
2. Press COPY.
3. Press the FORMAT key if the format line is to be copied.
4. Highlight text.
5. Press EXECUTE.
6. Position cursor at point where you wish to recall duplicate copy of text; press EXECUTE.

SUPER COPY

Super copy allows you to make an exact copy of text and position that text in a new document. Follow the steps listed below when super copying text.

1. Position cursor in newly created document (destination document).
2. Hold down the SHIFT KEY and press COPY.
3. Enter Document ID of document to be copied - the source document.
4. Position cursor under first character to be super copied.
5. Press EXECUTE.
6. Press FORMAT if format line is to be copied.
7. Highlight text.
8. Press EXECUTE.

MOVE

The move function deletes text from its original position and moves it to a new position within the same document. To move text, follow the steps listed below.

1. Position cursor under first character to be moved.
2. Press MOVE.
3. Press FORMAT if the format line is to be moved.
4. Highlight text.
5. Press EXECUTE.
6. Position cursor at position where you wish to recall text. Press EXECUTE.

SUPER MOVE

Super Move deletes text from its source document and moves it to an entirely new document - the destination document. Following the steps listed below will enable you to super move text.

1. Position cursor in destination document (newly created document) where text is to be moved.
2. Hold down the SHIFT KEY and press the MOVE key.
3. Enter the source document ID#.
4. Position cursor under first character to be super moved.
5. Press EXECUTE.
6. Press FORMAT if the format line is to be moved.
7. Highlight text to be moved.
8. Press EXECUTE.

Source: Wang Laboratories

PERFORMANCE/PRODUCT CHECKLIST

Program: SECRETARIAL OFFICE OCCUPATIONS

Task No: 170.B.8

Student's Name: _____ Date Of Attempt: _____

Evaluator's Name: _____ Evaluation Site: _____

Performance Attempt: 1 2 3 4

Terminal Performance Objective:

Given the needed Information, supplies, and equipment, copy and move text on the Wang OIS 60 Information System.

To measure your ability to perfrom this task, you must answer correctly 9 out of 10 questions on a written exam and score 22 out of 22 on a product checklist.

Directions To The Student:

Before attempting this task for mastery, carefully review this checklist. You will be evaluated on the basis of this checklist. When you feel you are ready for evaluation, contact your instructor. You must complete your performance within 25 minutes and must score at least 22 out of 22 points or 100 % for mastery. Critical items are marked with an asterisk (*). These items must be satisfactorily completed.

Directions To The Evaluator:

The student will contact you when ready for the evaluation. The student must complete the performance within 25 minutes and must score 22 out of 22 points or 100 % and all items marked with an asterisk (*) must be satisfactorily completed.

PERFORMANCE/PRODUCT CHECKLIST

170.B.8

Yes No

Part II

Vertical spacing is 1

Tab stop at 7

Line length 75

Text keyboarded as shown

Document summary printed

Hard copy printed

Part III

Vertical spacing is 1

Tab stop at 10

Line length 65

Text keyboarded as shown

Title centered and followed by a triple space

Last paragraph moved as directed

"undisclosed" inserted as directed

"expand" corrected

"skinny" corrected

"calorimeter" corrected

Document summary printed

Hard copy printed

Part V

destination document created

Radical Test to Count Calories supercopied

Document summary printed

Hard copy printed

PROJECT SUMMARY SHEET
170.B.8

Directions: This page is to be completed by your instructor.

Training Manual

_____ Conference

_____ List

_____ The Bells

_____ Testing Supercopy

_____ Copy

_____ Memo

_____ Hotel

_____ Seminar

Criterion Exam 170.B.8

_____ _____ _____ Part I

_____ _____ _____ Part II

_____ _____ _____ Part III

_____ _____ _____ Part V

Name _____ Date _____

Points _____

INFORMATION PROCESSING
SECRETARIAL OFFICE OCCUPATIONS
CRITERION EXAM
170.B.8

The purpose of this exam is to determine whether or not you have understood the procedures for copying and moving text on a Wang OIS 60 Information Processing System.

DIRECTIONS:

Written Exam

Write answers as directed on Part I of this test. A minimum score of 90 percent (9 answer correct) is required to pass this part of the exam.

Performance

Keyboard the document as directed in Part II of this exam. Make changes as indicated in Part III. Check your printout in Part III with the example shown in Part IV. Make any necessary corrections.
Make a super copy as directed in Part V of this exam. Part IV and V must be 100 percent accurate.

COPYING AND MOVING TEST
POST TEST 1
170.B.8

PART I

DIRECTIONS: Circle T if the answer is true; circle false if the answer is false.

T F 1. When you copy text using the copy key, the original text remains in place.

T F 2. When you move test using the move key, you remove text from its original position and position it in another place.

T F 3. To begin the copy or move function, position the cursor beneath the last character you want to copy or move.

T F 4. The text to be moved or copied must be highlighted.

T F 5. To complete the copy or move function, press COMMAND.

T F 6. To tell the system that you want to copy the alternate format line that precedes the text to be copied, press copy press FORMAT, highlight text to be copied, press EXECUTE.

T F 7. Copying text from one document into another document is known as super copying.

T F 8. When super copying text, the document you are copying from is the DESTINATION document; the document you are copying the text to is the SOURCE document.

T F 9. To give the instruction to begin super copy, press SHIFT and COMMAND.

T F 10. Moving text from one document into another document is known as super moving text.

PART II

Start time _____ Stop time _____

(15 minutes allowed)

DIRECTIONS: Keyboard the text that follows exactly as it appears. If there are any errors in the text, keyboard these exactly as they appear. Print a hard copy of text and the document summary.

Format Requirements: Vertical spacing 1; tab 7, linespace 75.

RADICAL TEST TO COUNT CALORIES

Conventional wisdom holds that skiny people have "high metabolism." U.S. Department of Agriculture (USDA) researchers have begun a study that will test the theory.

According to Wayne Marcus, two groups of volunteers, one lean and the other "moderately obese," will live in a facility adjoining the calorimeter for up to six months and be put on a strict diet-and-exercise regimen to keep their weight stable. During sessions inside the chamber, energy that a subject expends for metabolism and movement will be released as heat. This will be measured by the sensors. If the skinny people do indeed expand more energy, it would mean, says Marcus, that "some physical process we don't know about yet" is responsible.

The USDA is now looking for volunteers who will be paid an sum to donate a half-year to science.

To measure whether lean people routinely expend more energy than heavier people, they have installed a human calormeter—a chamber whose walls contain 16,000 sensors that can detect changes in temperature of less than a thousandth of a degree Celsius.

SOURCE: SCIENCE DIGEST, SEPTEMBER, 1984.

Start time _____ Stop time _____

PART III

(5 minutes allowed)

DIRECTIONS: Make changes in text that follows as indicated. Print a hard copy of text and the document summary.
Format Requirements: Vertical spacing 1; tab 10, linespace 65.

---

center

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undisclosed

To measure whether lean people routinely expend more energy than heavier people, they have installed a human calormeter—a chamber whose walls contain 16,000 sensors that can detect changes in temperature of less than a thousandth of a degree Celsius.

Instructor must observe while you move this data.

SOURCE: SCIENCE DIGEST, SEPTEMBER, 1984.

PART IV

DIRECTIONS: Check your final draft against the copy that follows.

RADICAL TEST TO COUNT CALORIES

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The USDA is now looking for volunteers who will be paid an undisclosed sum to donate a half-year to science.

SOURCE: SCIENCE DIGEST, SEPTEMBER, 1984.

Start time _____ Stop time _____

PART V (5 minutes allowed)

DIRECTIONS: Create a destination document. Super Copy document from Part IV.

Instructor must observe super copying _____

Print a hard copy of this document.

Return a hard copy of Part II, IV, and V along with the written exam to your instructor.

DOCUMENT SUMMARIES MUST BE HANDED IN WITH EACH PRINTED EXERCISE.

All documents created while working on Guide 170.B.8 and this criterion exam should be filed to your diskette.

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COMPETENCY-BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

STUDENT LEARNING GUIDE

Produced By J Robinson Date 01/28/85

TASK: Perform advanced formatting on the Wang OIS 60 Information Processing System.

PURPOSE: The advanced formatting feature on the Wang allows the operator to recall a primary format line, delete an alternate formate line; print with boldface and double underscores, hyphenate text, and create headers and footers.

INFORMATION PROCESSING

Program	Task	Est.Time	Prereq.
SOO	170B9	12 hours	170B1 - 170B8

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME _____ SOCIAL SECURITY NUMBER _____

LENGTH OF CONTRACT (NORMAL TIME IN HOURS) _____

2. TERMINAL PERFORMANCE OBJECTIVE

Given a Wang OIS 60 Information Processing System, the needed data, and supplies, perform advanced formatting.

To master this task you must score 18 out of 20 on a written criterion exam and 17 out of 17 on a product checklist.

2a. INTERMEDIATE OBJECTIVE(s)

1. Perform advanced formatting on the Wang OIS 60 Information Processing System.

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____. I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

Student's Signature _____ Instructor's Signature (verifies competency) _____

INTERMEDIATE OBJECTIVE #1

Perform advanced formatting on the Wang OIS 60 Information Processing System.

LEARNING STEPS (Activities)

1. See Resource #1 to recall a primary format line.
2. To delete an alternate format line, see Resource #2.
3. See Resource #3 to center headings over columns.
4. To type attributes for underscore, double underscore, strike thru, boldface, sub and superscript, see Resource #4.
5. See Resource #5 to hyphenate text.
6. Complete Resource #6 to protect pages during pagination.
7. To create headers and footers, see Resource #7.
8. To review, complete Resource 8 A & B.
9. To measure your ability to perform advanced formatting, see Resource #9A and 9B.

RESOURCES

1. Read pages 9-4 to 9-7 in ADVANCED FORMATTING completing exercise as directed.
2. Read pages 9-8 to 9-11 in ADVANCED FORMATTING completing exercise as instructed.
3. Read instructions and complete exercise as directed on pages 9-12 to 9-15 in ADVANCED FORMATTING.
4. Read pages 9-16 to 9-33 in ADVANCED FORMATTING completing exercises as directed.
5. Read pages 9-34 to 9-42 in ADVANCED FORMATTING. Complete exercise as directed.
6. Read pages 9-43 to 9-45 in ADVANCED FORMATTING. Complete exercise as instructed on pages 9-46 to 9-47 in ADVANCED FORMATTING.
7. Read pages 9-50 to 9-55 in ADVANCED FORMATTING. Complete exercise as directed on pages 5-57 to 5-59 of ADVANCED FORMATTING.

8A. Read guide pages 4 to 8.

8B. Complete skill building exercises on pages 9-66 to 9-78 in ADVANCED FORMATTING.

9A. Product/Performance Checklist guide pages 9 to 10.

9B. Criterion Exam 170.3.9.

ADVANCED FORMATTING
INFORMATION SHEET #1

RECALLING THE PRIMARY FORMAT LINE

After typing a table within a document, you may wish to return to the format specified at the beginning of the document - to return to the primary format line.

1. Position the cursor under the end-of-text character(.).
2. Press Format. (The settings found in the Alternate format line will be displayed.)
3. Press Format again. The format line will display the same settings as the Primary format line.

DELETING ALTERNATE FORMAT LINES

When editing copy, you may decide to delete an Alternate format line. Text that follows the deleted Alternate format line will adjust to the settings in the immediately preceding format line.

To delete an Alternate format line,

1. Position the cursor in the Alternate format line you wish to delete. Press FORMAT or SHIFT and FORMAT to do this.
2. Press DELETE.

   NOTE: PRIMARY FORMAT LINES MAY BE ALTERED BUT THEY MAY NOT BE DELETED.

CENTERING HEADINGS OVER COLUMNS

Centering headings over columns on a word processor is similar in many ways to centering headings over columns on a typewriter. Before you type the headings, you should enter a line of spaces. Remember on the Wang OIS 60, you cannot type where characters have not been keyboarded.

Follow these steps to center headings, after the columns have been typed.

1. Locate the beginning of the first character in the longest word in Column 1.
2. Space forward 1 time for every 2 characters to find the center of Column 1.
3. Backspace 1 time for every 2 characters in the column heading.
4. At the point where you finished backspacing, begin to type the heading.
5. To center the column heading for the second column, follow steps 1 - 4.

NOTE: A DETAILED ILLUSTRATION MAY BE FOUND ON PAGE 9-13 OF ADVANCED FORMATTING.

Follow these steps to center the column heading before the column has been typed.

1. Find the longest word in Column 1.
2. Subtract the number of spaces found in the column heading from the number of spaces in the column.*

Feeder High Schools (19)

Waukegan East High School (25)

```
    25
 -  19
    --
     6  divided by 2 = 3
```

3. From the beginning of Column 1, space forward 3 times and begin to type the column heading.
4. Repeat steps 1-3 for succeeding columns.

NOTE: IF THE HEADING IS LONGER THAN THE COLUMN, YOU WILL WANT TO CENTER THE LONGEST WORD IN THE COLUMN UNDER THE COLUMN HEADING.

TYPING ATTRIBUTES

Attributes are special characteristics added to a letter or a number. These include underscore, double underscore, strike thru, boldface, superscript, and subscript. Attributes may not be added to screen graphics.

Underscore is used to emphasize words or when typing footnotes.

1. Position cursor under first character to be underscored.
2. Hold down SHIFT and type underscore once for each character to be underscored.

Removing Underscores

NOTE: YOU MAY CHOOSE TO RETYPE UNDERSCORED TEXT WITHOUT AN UNDERSCORE. THIS WILL REMOVE THE UNDERSCORE.

ADVANCED FORMATTING
INFORMATION SHEET #1

Autoscore automatically underscores text as it is typed.

1. Press COMMAND.
2. Hold down SHIFT and press UNDERSCORE.
3. Type text.
4. To end underscore, press COMMAND, hold down SHIFT and press UNDERSCORE.

Double Underscore will double underline text. Generally, it would be used for accounting purposes for underlining total assets, liabilities, and owners equity.

1. Press Subscript key.
2. Backspace and underscore the down arrow. ↓
3. Type text.
4. Underscore text.

Boldface creates text that is darker than other text because the letters have been typed a second time. To boldface text, follow the steps listed below.

1. Hold down SHIFT and press Superscript (up arrow). ↑ text ↑
2. Underscore the up arrow.
3. Type text.
4. Hold down Shift and press Superscript (up arrow).
5. Underscore the up arrow.

Strike Thru types a diagonal line through text. Follow these steps to strike through text.

1. Press Subscript key two times. ↓↓
2. Underscore both down arrows.
3. Type text.
4. Underscore text.

Superscript allows the operator to type numbers above the line as in 10^5. Follow the steps listed below when creating superscripts.

1. Press Superscript.
2. Type text. 10 ↑5↓
3. Press Subscript.

To remove superscript, delete up and down arrows.

Subscript allows the operator to type numbers below the line as in H_2O.

1. Press Subscript.
2. Type text. H↓2 ↑0
3. Press Superscript.

To remove subscript, delete up and down arrows.

HYPHENATING TEXT

Hyphenating text will create a more even right margin; it is especially important to hyphenate text that you intend to justify.

Follow the steps listed below when hyphenating text.

1. Press COMMAND.
2. Press the HYPHEN (-) KEY.
3. Enter the zone length 3 - 99.
4. Press EXECUTE.
5. Position cursor under letter to follow hyphen within highlighted zone.
6. Press EXECUTE. (IF YOU DECIDE NOT TO HYPHENATE THE WORD, PRESS SRCH.)

To remove hyphens,

1. Press COMMAND.
2. Press HYPHEN (-).
3. Enter 99 as zone length.
4. Press EXECUTE.

PAGINATION

There are times you will not want to delete an existing page break when you automatically paginate a document. For instance, after a title page, around a chart, or a the beginning of a new chapter you may wish to keep pagination as it is.

To protect pages during pagination, follow the instructions listed below.

1. Move the cursor under the page break symbol ( ) that comes before the page you want protected.
2. Depress INSERT.
3. Depress CENTER.

4. EXECUTE.
5. Position cursor under page break on page to be protected.
6. Depress INSERT.
7. Depress CENTER.
8. Depress EXECUTE.

CREATING HEADERS OR FOOTERS

Headers are found at the top of pages while footers are found at the bottom of pages. Headers may include identifying information. Footers almost always include a page number. The OIS 60 will automatically number pages for the operator.

Follow these instructions to create a header.

1. Press GO TO.
2. Enter H (for header). A blank page appears.
3. Press INSERT.
4. Type header information.
5. Press EXECUTE.

Follow these instructions to create a footer.

1. Press GO TO.
2. Enter F (for footer). A blank page appears.
3. Press INSERT.
4. Type footer information. For page numbering, type #. The system will automatically count and put in the correct page number.
5. Press EXECUTE.

To print headers and footers,

1. Select PRINT DOCUMENT.
2. Enter ID #; press EXECUTE.
3. Enter starting page number for header usually page 2.
4. Enter starting page number for footer usually page 2. (Pages should be numbered in either the header or footer - not in both places.)
5. Enter line on which footer is to begin usually 57.
6. Complete remainder of Print Document Menu.
7. Press Execute.

PERFORMANCE/PRODUCT CHECKLIST

Program: INFORMATION PROCESSING/SECRETARIAL OFFICE OCCUPATIONS

Task No: 170.B.9

Student's Name: _____ Date Of Attempt: _____

Evaluator's Name: _____ Evaluation Site: _____

Performance Attempt: 1 2 3 4

Terminal Performance Objective:

Given a Wang OIS 60 Information Processing System, the needed data, and supplies, perform advanced formatting.

To master this task, you must score 18 out of 20 on a written criterion exam and 17 out of 17 on a product checklist.

Directions To The Student:

Before attempting this task for mastery, carefully review this checklist. You will be evaluated on the basis of this checklist. When you feel you are ready for evaluation, contact your instructor. You must complete your performance within _____ minutes and must score at least _____ out of _____ points or 100 % for mastery. Critical items are marked with an asterisk (*). These items must be satisfactorily completed.

Directions To The Evaluator:

The student will contact you when ready for the evaluation. The student must complete the performance within _____ minutes and must score _____ out of _____ points or 100 % and all items marked with an asterisk (*) must be satisfactorily completed.

CRITERION EXAM 170.B.09

PART I - WRITTEN CRITERION EXAM

	Yes	No
Minimum score of 90 percent required.	___	___

PART II - TABLE

Centered both vertically and horizontally.	___	___
Body of table double spaced.	___	___
Columnar headings centered over columns.	___	___
Numbers aligned at decimal.	___	___
Single and double underscore where shown.	___	___
All errors corrected.	___	___
Title should be all capital letters, centered, and printed in bold print.	___	___

PART III - ARTICLE

Used a 75-space line.	___	___
Paragraphs indented 5 spaces.	___	___
Vertical spacing is 1 1/2.	___	___
All words should appear underscored as shown.	___	___
Title typed in all capital letters and centered.	___	___
Title should be followed by a triple space.	___	___
Text hyphenated.	___	___
Header must appear on all pages.	___	___
Footer must appear on all pages except the first.	___	___
All errors corrected.	___	___

PROJECT SUMMARY SHEET

170.B.9

CRITERION EXAM

Part I - Written Exam	_____	_____	_____
Part II - Tabulated Data	_____	_____	_____
Part III - Report	_____	_____	_____

EXERCISES

Job Fair	_____
Budget Review Memo	_____
Hyphenating Practice	_____
Required Page Break	_____
What is Word Processing?	_____
Annual	_____
Office Information Center	_____
Annual Report Memo	_____
Marquis	_____

NAME _____ DATE _____

SCORE _____

SECRETARIAL OFFICE OCCUPATIONS
Information Processing
Criterion Exam
Task #170.B.9

The purpose of this exam is to determine whether or not you have understood the procedures for performing advanced printing on the OIS 60 Wang Information Processing System.

DIRECTIONS:

PART I

Write your answer(s) on the blanks provided. Use ink. Make certain that all writing is legible. A minimum score of 90 percent is required on Part I of this exam.

PARTS II AND III

Keyboard text as directed. Instruction involving formatting of text must be followed. All errors must be corrected. A minimum score of 100 percent is required for these parts of the exam.

ADVANCED PRINTING
CRITERION TEST #1
170.B.09

PART I

DIRECTIONS: On the blank provided, write the letter that comes before the correct answer. A minimum score of 90 percent is required.

____ 1. To return to the format specified in the primary format line after typing a table that used an alternate format line, press

a. FORMAT 1 time
b. FORMAT 2 times
c. SHIFT + FORMAT 1 time
d. SHIFT + FORMAT 2 times

____ 2. To delete an alternate format line, position the cursor in the alternate format line, then press

a. INSERT
b. ERASE
c. COMMAND
d. DELETE

____ 3. When typing columnar headings, you should

a. not worry about centering the headings
b. should center the headings over the columns
c. should line up the heading and the column at the left
d. both a and c

____ 4. To center the column heading before the column is typed, subtract the difference between the heading and the column then

a. position the cursor at the beginning of the column and space forward once for the difference between the longest word in the column and the column heading.
b. position the cursor at the end of the column and space forward once for the difference between the longest word in the column and the column heading.
c. position the cursor at the beginning of the column and space forward for half the difference between the longest word in the column and the column heading.
d. none of the above.

ADVANCED PRINTING
CRITERION TEST #1
170.B.09

____ 5. To underscore a word that has already been typed, use the west cursor key to move to the beginning of the word,

a. press COMMAND, SHIFT + UNDERSCORE
b. hold down SHIFT and press UNDERSCORE for each character to be typed.
c. hold down COMMAND and press UNDERSCORE for each character to be typed.
d. all of the above.

____ 6. To autoscore text while typing,

a. press COMMAND, SHIFT + UNDERSCORE
b. hold down SHIFT and press UNDERSCORE for each character to be typed.
c. hold down COMMAND and press UNDERSCORE for each character to be typed.
d. all of the above.

____ 7. To begin double underscoring,

a. keyboard an underscored up arrow (superscript) at the beginning and the end of text.
b. keyboard two down arrows (subscripts) at the beginning of text.
c. keyboard an up arrow (superscript) at beginning of text and a down arrow (subscript) at end of text.
d. keyboard an underscored down arrow (subscript) at the beginning of text and under text to be underlined.

____ 8. To type in boldface,

a. keyboard an underscored up arrow (superscript) at the beginning and the end of text.
b. keyboard two down arrows (subscripts) at the beginning of text.
c. keyboard an up arrow (superscript) at beginning of text and a up arrow (superscript) at end of text.
d. keyboard an underscored down arrow (subscript) at the beginning of text.

___ 9. To strike through text,

a. keyboard an underscored up arrow (superscript) at the beginning and the end of text.
b. keyboard two underscored down arrows (subscripts) at the beginning of text and underscore the text.
c. keyboard an up arrow (superscript) at beginning of text and a down arrow (subscript) at end of text.
d. keyboard an underscored down arrow (subscript) at the beginning of text.

___ 10. To type a superscript (number above the line),

a. keyboard up arrow (superscript), type number, keyboard down arrow (subscript).
b. keyboard two up arrows (superscripts) type number.
c. keyboard up arrow (superscript), type number, continue to type remaining text.
d. keyboard up arrow (superscript), type number, keyboard a second superscript or up arrow.

___ 11. To type a subscript (number below the line),

a. keyboard down arrow (subscript), type number, keyboard down arrow (subscript).
b. keyboard two down arrows (subscripts) type number.
c. keyboard down arrow (subscript, type number, continue to type remaining text.
d. keyboard down arrow (subscript), type number, keyboard a superscript or up arrow.

___ 12. Text should be hyphenated

a. to make the right margin more even.
b. when you plan to justify the text.
c. both a and b.
d. none of the above.

___ 13. The command that hyphenates text is

a. COMMAND + AMPERSAND KEY
b. COMMAND + - KEY
c. COMMAND + # KEY
d. COMMAND + SUPERSCRIPT KEY

ADVANCED PRINTING
CRITERION TEST #1
170.B.09

___ 14. To protect pages from repagination, ——— the page break graphic.

a. indent
b. insert
c. delete
d. center

___ 15. To create a header page,

a. press COMMAND and H
b. press GO TO and H
c. press HEADER key
d. press Super/subscript and H

___ 16. Headers usually appear

a. at the bottom of the page
b. on the title page only
c. in the bibliography only
d. at the top of the page

___ 17. To instruct the OIS 60 to number pages in either a header for footer,

a. keyboard a $.
b. keyboard a #.
c. keyboard a ".
d. keyboard an *.

___ 18. To keyboard data on either a header or footer page, the operator must first depress

a. INSERT.
b. COMMAND + INSERT.
c. SHIFT + INSERT.
d. SHIFT + COMMAND + INSERT.

___ 19. To return to the document from the header or footer page,

a. Press CANCEL and EXECUTE.
b. Press RETURN.
c. Press COMMAND + EXECUTE.
d. Press GO TO and document page number, execute.

ADVANCED PRINTING
CRITERION TEST #1
170.B.09

____ 20. To print a header or footer, you must complete the

a. Special Print Functions Menu
b. Document Index
c. Print Document Menu
d. Document Header Menu

ADVANCED PRINTING
CRITERION TEST #1
170.B.09

PART II

DIRECTIONS: Type the table that follows. Center both vertically and horizontally. Double space the body of the table. Columnar headings must be centered over the columns. Numbers must be aligned at decimal. Single and double underscore must appear where shown. All errors must be corrected.

Print RECOMMENDED SALARY INCREASES in bold print.

RECOMMENDED SALARY INCREASES

To Be Effective September 1

Employee	Present	Increase	Percent	New
Felton, L. F.	$100.00	$10.00	10.0%	$110.00
Bernhardt, D. A.	85.00	8.50	10.0%	93.50
Greer, J. L.	120.00	9.60	8.0%	129.60
Hunter, C. K.	90.00	9.00	10.0%	99.00
TOTAL	$395.00	$37.10	38.0%	$432.10

SOURCE UNKNOWN

ADVANCED PRINTING
CRITERION TEST #1
170.B.09

PART III

DIRECTIONS: Type the article that follows. Use a 75 space line with a five space tab indention. Set vertical spacing at 1 1/2. All words should be underscored as shown. The title should be typed in all capital letters, centered and followed by a triple space.

Include the footnote. Type as shown.

Type the following header: Software Review. The header should appear on all pages including the first.

The footer should include a page number on pages with the exception of the first.

Hyphenate document. Correct any errors made.

SOFTWARE REVIEW

GRAPHICS PROGRAMS TURN HOME COMPUTER INTO EASEL

Not everyone can be born an artist. But with the help of computer software, nearly anyone can feel like one. Two popular programs, The Arcade Machine and The Graphics Magician, exemplify the new breed. The Arcade Machine is designed to make it easy to produce Invader-style video games in which the "enemy" is at the top of the screen and the player at the bottom. The first choice from the software's Main Menu is the Shape Creator. This allows you to design crawly-but-cute creatures by using the keyboard to "turn on" tiny blocks of color; the process is similar to assembling a mosaic of titles. You then use the Path Creator to move your shapes around the screen.

The Graphics Magician is similar, but more versatile, and thus requires a bit of programming knowledge. With the Magician, you can easily animate shapes anywhere on the screen, but such things as detecting "hits" and scoring are left to the ingenuity of the programmer.

Suppose, however, you're not a game nut. Suppose you'd rather produce the computerized counterpart to the Mona Lisa. Take heart: New Programs that allow you to "paint" on-screen are more versatile than ever before.

The Complete Graphics System is just about what its name implies. With this program, you can use your imagination to achieve special effects available in no other artistic medium.

Like many programs, this one works best with a joystick. By manipulating the handle, you can move about the screen and leave a trail of color behind you. However, just as the oil painter might want one brush for pointillistic dottings and another for thick layers of impasto, so on your video screen you will want different "brushes" to achieve different effects. The Complete Graphics System provides these in the form of predefined shapes that leave thin or thick lines and even create textures from rough to dappled to diaphanous.

But as good as many of these software schemes are, most depend on an ordinary keyboard or joystick, and thus, may lack flexibility. A new device called the Koalapad can change all this. Compatible with any Apple, Commodore 64 or Atari machine, the Koalapad is essentially a small, touch-sensitive square, measuring four inches on each side. Using the fingertip or stylus, the computer artist simply "draws" on the tablet while watching the screen.

For getting kids interested in computers, nothing comes close to Koalapad. Even very young children grasp the concept of drawing on-screen.

Neil Shapiro

[1] Neil Shapiro, "Graphics Programs Turn Home Computers Into Easel," Science Digest, Vol. 92 No. 9 (September, 1984) p. 86.

LAKE
COUNTY
AREA
VOCATIONAL
CENTER

COMPETENCY-BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

STUDENT LEARNING GUIDE

Produced By J Robinson Date 02/03/85

TASK: Perform advanced printing on the Wang OIS 60 Information Processing System.

PURPOSE: The advanced print feature on the Wang OIS 60 allows the operator to stop printing to change print wheels and to print text with proportionally spaced characters.

INFORMATION PROCESSING

Program	Task	Est.Time	Prereq.
SOO	170B10	4 hours	170B1 to 170B9

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME _____ SOCIAL SECURITY NUMBER _____

LENGTH OF CONTRACT (NORMAL TIME IN HOURS) _____

2. TERMINAL PERFORMANCE OBJECTIVE

Given a Wang OIS 60 Information Processing System, the needed data, and supplies, perform advanced printing.

To master this task, you must score 12 out of 13 on a written criterion exam and 18 out of 18 on a product checklist.

2a. INTERMEDIATE OBJECTIVE(s)

1. Stop the printer, change print wheels, and print proportionally spaced text on a Wang OIS 60 Information Processing System.

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____. I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

Student's Signature _____

Instructor's Signature (verifies competency) _____

INTERMEDIATE OBJECTIVE #1

Stop the printer, change print wheels, and print proportionally spaced text on the Wang OIS 60.

LEARNING STEPS (Activities)

1. To learn how to stop the printer and change the print wheel, complete Resource #1.
2. See Resource #2 to gain proficiency in stopping the printer and changing print wheels.
3. Complete Resource #3 to learn how to print proportionally spaced text.
4. To print text proportionally spaced, see Resource #4.
5. To review, complete Resource #5.
6. To measure your ability to stop the printer, change print wheels, and print text proportionally spaced, complete Resource #6A and #6B.

RESOURCES

1. Read pages 10-2 to 10-5 in WANG - ADVANCED PRINTING. Also, read pages 4 to 8 in this guide - Printing Information Sheet #1.

   Request that your instructor demonstrate print wheel removal and replacement on the printer you will be using.
2. Complete exercises on page 10-6 to 10-8 in WANG - ADVANCED PRINTING.
3. Read page 10-9 in ADVANCED PRINTING. Read page 9 in this guide - Information Sheet #2.
4. Complete exercises on pages 10-10 to 10-22 in WANG ADVANCED PRINTING.
5. A. Read pages 10-23 to 10-25 in WANG ADVANCED PRINTING.

   B. Complete skill building exercises on pages 10-26 to 10-30 in WANG ADVANCED PRINTING.
6. A. Product/Performance Checklist on guide pages 10-11.

   B. Criterion Exam 170.B.10.

ADVANCED PRINTING
170.B.10

STOPPING THE PRINTER

It is possible to print text in different type styles on the OIS 60 INFORMATION PROCESSING SYSTEM. To do this, you must stop the printer during print out.

Press the stop key (a ■ graphic appears on the screen) wherever you wish the printer to stop. You will then install a new print wheel. This stop feature is available only on character printers.

The print document menu must be adjusted as follows.

- Character set number must be entered for each print wheel.
- If the print wheel character set numbers are the same, you need only enter one number on the PTR 20. Other printers require that both numbers be entered even though they are the same.

PRINT DOCUMENT

Document Id
Document Name

Print from Page:
First Header Page:

Print thru. Page:
First Footer Page:

Starting as Page No.
Footer Begins on Line:

Page Length:
Printer No.

No. of Originals:
Left Margin:

Character Set No.: 3 8
(1st character set)
(2nd character set)

Please select one from each column:

DEVICE	PITCH	FORMAT	FORMS	STYLE	SUMMARY	DELETE
. Character	. 10	. Unjustified	. Continuous	. Final	. Print	. No
. Line	. 12	. Justified	. Standard	. Draft	. Omit	. Yes
. Photocomp.	. PS	. With Notes	. Form 1			
. Image	. 15		. Form 2	LINES PER INCH	. 6	. 8

Instructions for changing the print wheel on Printer No. 5 follow.

PRINT WHEEL REPLACEMENT

WARNING

Always press DESELECT before attempting to replace a print wheel. Accidentally selecting the printer could cause a print wheel to begin printing while your hands are in the printer.

1. Press DESELECT and open the sound panel.
2. Push down the print wheel release latch (Figure 3-3) to unlock the print wheel compartment. The compartment will pop open.
3. Carefully remove the print wheel by gently lifting it out by its spokes. Store it in its plastic container for future use.

CAUTION

The print wheel is rugged and dependable, but it can be damaged. Avoid bending its spokes when handling it. Always store it in its plastic container when it is not installed in the printer.

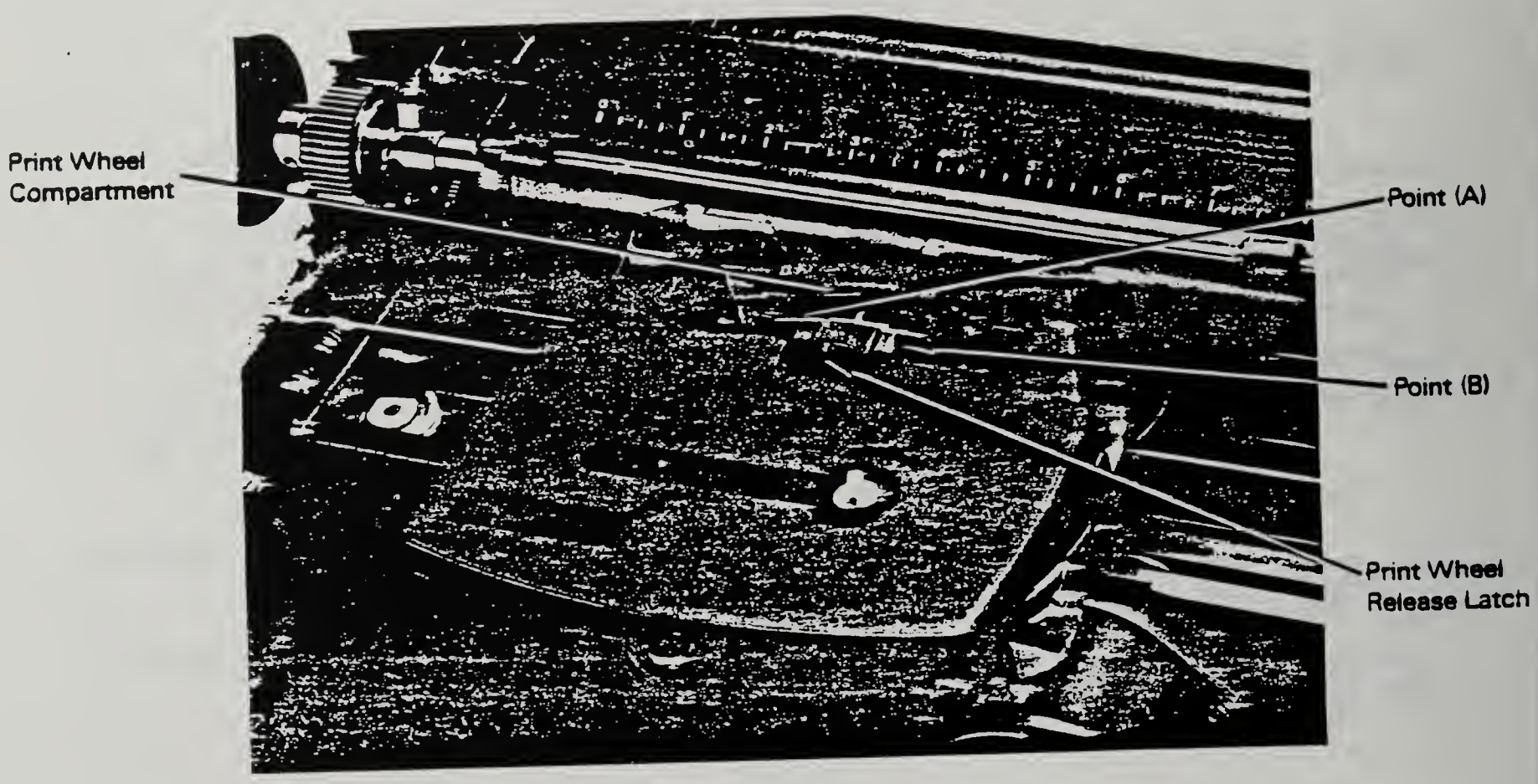

Figure 3-3. Print Wheel Removal/Replacement

4. Carefully and lightly grasp the replacement print wheel by its spokes and gently drop it down into the print wheel compartment, making sure the side with the characters faces the platen and the wheel is not inserted between the ribbon and the platen.

5. Push at Point A or B (Figure 3-3) to move the print wheel compartment toward the platen so the print wheel release latch can be pushed home to lock the compartment in its operating position. Close the sound panel.

6. If printing is interrupted for a print wheel change, press SELECT to continue printing.

Instructions for changing the print wheel on Printer No. 12 follow.

CHANGING THE PRINT WHEEL

Use the following procedure to remove and install a print wheel in the printer. Use care when removing, installing, or storing a print wheel. Use plastic wheels only, as metal print wheels may damage the printer.

1. Open the front cover by gently lifting the back edge of the printer front cover.

2. Grasp the print hammer and gently tilt the print wheel assembly away from the platen (refer to Figure 3-7).

Figure 3-7. Tilting the Print Wheel Assembly

3. To remove the print wheel, grasp the rubber hub and gently pull the print wheel upward and away from the printer (refer to Figure 3-8).

Figure 3-8. Removing the Print Wheel

4. To install a print wheel, hold the wheel so that the edge of the wheel is under the ribbon. Then rotate the wheel so the tab protruding from the shaft hub lines up with the alignment slot on the print wheel (refer to Figure 3-9). Push the wheel firmly onto the end of the print wheel shaft, making sure the tab enters the alignment slot on the wheel. Then grasp the print hammer and push it toward the platen until it clicks into position.

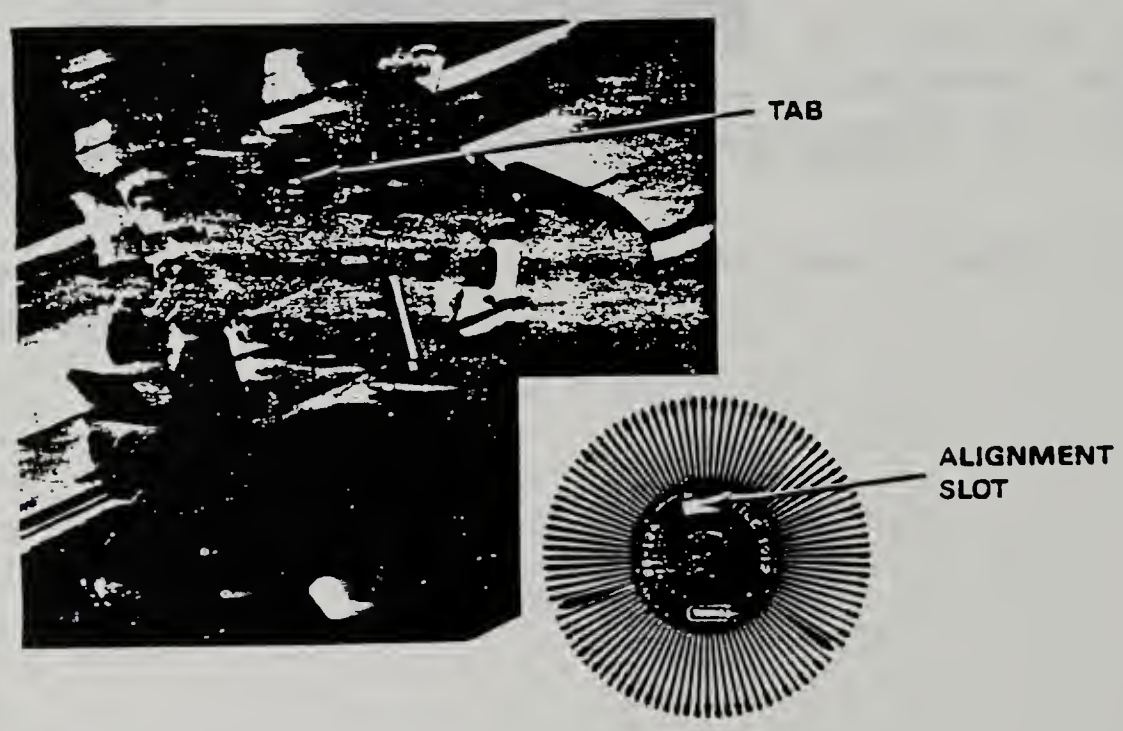

Figure 3-9. Tab and Alignment Slot Locations

SOURCE: WANG LABORATORIES

PROPORTIONALLY SPACED TEXT

In proportional spacing each character uses a different amount of space. Notice that the text printed on this page is printed in proportional spacing.

When you use a 10-, 12-, or 15-pitch print wheel each character uses the same amount of space.

To print proportionally spaced, you must follow these steps.

1. Install a proportionally spaced print wheel
2. Select "Print Document" from the word processing menu
   A. Enter the correct character set number
   B. Select PS under pitch

Text will not appear proportionally spaced on the screen. For this reason you must follow special rules when printing with proportional spacing.

Tabulated Text

1. Set only one tab stop for each column - do not set extra tab stops between columns.

2. Allow plenty of space between columns.

Hyphenating Text

1. Print document to determine if you need to hyphenate.

2. Insert a hyphen and a space when you feel you need to divide a long word.

Underscoring Text

1. Underscore words in usual manner - lines will lengthen as required to underscore text.
2. When underscore is used alone, it shortens (from what appears on the screen) by 1/3.

PERFORMANCE/PRODUCT CHECKLIST

Program: SECRETARIAL OFFICE OCCUPATIONS/INFORMATION PROCESSING

Task No: 170.B.10

Student's Name: _____ Date Of Attempt: _____

Evaluator's Name: _____ Evaluation Site: _____

Performance Attempt: 1 2 3 4

Terminal Performance Objective:

Given a Wang OIS 60 Information Processing System, the needed data, and supplies, perform advanced printing.

To master this task, you must score 12 out of 13 on a written criterion exam and 18 out of 18 on a product checklist.

Directions To The Student:

Before attempting this task for mastery, carefully review this checklist. You will be evaluated on the basis of this checklist. When you feel you are ready for evaluation, contact your instructor. You must complete your performance within 50 minutes and must score at least 18 out of 18 points or 100 % for mastery. Critical items are marked with an asterisk (*). These items must be satisfactorily completed.

Directions To The Evaluator:

The student will contact you when ready for the evaluation. The student must complete the performance within 50 minutes and must score 18 out of 18 points or _____ % and all items marked with an asterisk (*) must be satisfactorily completed.

PERFORMANCE/PRODUCT CHECKLIST

ARTICLE - "OLD" SMOKE IS STILL BAD SMOKE

YES	NO	
___	___	*Linespace is 70. (Margins must be even.)
___	___	*Vertical spacing is 1.
___	___	*Tabs are at 5, 10, 15.
___	___	*Printout is proportionally spaced.
___	___	*Printout is justified.
___	___	*All errors corrected.
___	___	*Paragraphs indented 5 spaces.
___	___	*Headings are centered.
___	___	*A triple space follows the heading.
___	___	*One blank line appears between paragraphs.
___	___	*In second printout, the second paragraph is printed in a different type style.

TABULATION - DELTA PI EPSILON

___	___	*There are six spaces between columns.
___	___	*There is a 2-inch top margin.
___	___	*Vertical spacing is 2.
___	___	*Printout is proportionally spaced.
___	___	*Right and left margin are equal.
___	___	*A triple space follows the main heading.
___	___	*All keyboarding errors corrected.

PROJECT SUMMARY SHEET 170.B.10

Exercises completed as directed.

STOCKHOLDERS _____

PROPORTIONAL SPACE _____

COLORS _____

CUMBERSOME TYPING _____

INSURANCE PLANS _____

THE FOX _____

NEW ACCOUNTS _____

CRITERON EXAM

PART I	_____	_____	_____
PART II	_____	_____	_____
PART III	_____	_____	_____
PART IV	_____	_____	_____

NAME _____ DATE _____

POINTS _____

SAVE THIS PAGE!!!!

PERFORM ADVANCED PRINTING
170.B.10

The purpose of this exam is to determine whether or not you have understood the information presented on advanced printing on a Wang OIS 60 Information Processing System.

Directions:

PART I

Write your answers in the space provided to the left of the question. Select the answer that best completes or defines the statement. A minimum score of 90 percent is required.

PART II

Keyboard the document as directed. Follow all instructions given for formatting the text. Correct any errors made. A maximum time of 30 minutes will be allowed to complete this part of the examination.

PART III

Print out the article "'OLD' SMOKE IS STILL BAD SMOKE" using stop codes. Instructor must observe.

PART IV

Keyboard the list of officers as directed. All errors must be corrected. Follow all instructions given for formatting the text. A maximum time of 20 minutes will be allowed to complete this part of the examination.

NAME _____ DATE _____

PART I

PERFORM ADVANCED PRINTING
170.B.10

DIRECTIONS: Select the answer that best completes or defines the statement. Write the letter that comes before the correct answer on the blank provided.

____ 1. To print document that use more than one type style, you must ——— the printer to install the appropriate print wheel.

____ 2. The stop function is available only on ———— printers.

____ 3. You must use ————(#) of stop graphics when printing in two different type styles.

____ 4. When printing text that has stop graphics, you must enter one character set for each different ————————————.

____ 5. To add a stop graphic, you must press ———, press ———, and press ———.

____ 6. On a proportionally spaced print wheel, each character is assigned a ———— unit value.

____ 7. To print proportionally spaced text, you must install a ——— spaced print wheel on the printer and select ——— from the print document menu.

____ 8. Characters ————— (do/do not) display on the screen proportionally spaced, each character uses the same amount of space on the screen.

____ 9. Tabbed text ————— (may/may not) align when you print it using a proportionally spaced print wheel.

____ 10. To avoid misaligning proportionally spaced columnar text, you should set ——— tab stop between columns and allow ——— of space between tab stops.

____ 11. To hyphenate proportionally spaced text, insert a ——— and a ——— at the correct position.

____ 12. When you use the underscore character alone (to print a line) in proportionally spaced text, the line shortens by approximately ———.

____ 13. Text ——— (will/will not) print out exactly as it appears on the screen when using proportional spacing.

Write the letter that comes before the correct answer on the line provided. You may use each answer only one time.

A. line
B. stop
C. will
D. will not
E. may
F. may not
G. do
H. do not
I. plenty
J. PS
K. proportionally
L. one
M. two
N. stop
O. character
P. print wheel
Q. space
R. different
S. execute
T. hyphen
U. insert
V. 1/3
W. 1/4
X. 1/5

PART II

Directions: Type the article that follows. Correct any errors you make.

Format Requirements: Linesp. 70, Vertical spacing 1, Tabs 5, 10, 15
Proportional Spacing, Copy Justified

"OLD" SMOKE IS STILL BAD SMOKE / 1.5.

Can inhaling the smoke from other people's cigarettes be hazardous to your health? According to one recent study, nonsmokers who spend time in smoke-filled rooms may run a greatly increased risk of smoke and heart attack.

Helmut Sinzinger and a research team at the University of Vienna Medical School put nine nonsmokers in a room filled with smoke from 30 cigarettes. After 15 minutes they tested the subjects' platelets—clot-forming particles in the blood—for sensitivity to prostaglandins, blood-borne chemicals that keep platelets from sticking together. Tests have demonstrated a strong link between this sensitivity and heart attack and stroke.

The platelets were found to be 75 percent less sensitive than usual; in other words, the prostaglandins were largely blocked from doing their job, greatly increasing the nonsmokers' risk of developing life-threatening blood clots. Even an hour after leaving the smoky room, sensitivity was still substantially lowered.

Although smokers exposed to the same conditions had no significant response, regular smoking had permanently cut their platelet sensitivity in half.

Sinzinger says that nonsmokers in smoky atmospheres may run about the same risk of stroke and heart attack as those who regularly smoke up to a pack a day. And, given their lower tolerance to smoke, even an occasional puff may be dangerous to those who don't smoke.

0007S

SOURCE: SCIENCE DIGEST - 1984

PART III

Directions: Insert stop codes before the "H in Helmut and after stroke." in the second paragraph of the article you just printed.

During print out, change the print wheel so that the second paragraph of this article is printed in a different type style from the rest of the article. PRINT THE DOCUMENT SUMMARY.

Instructor must observe as you perform this operation.

PART IV

Directions: Type the list of officers that follows. Correct any errors you make while keyboarding.

Format Requirements: 6 spaces between columns, 2-inch top margin, vertical spacing 2, print in proportional spacing

DELTA PI EPSILON

Chapter Executive Board and Officers

Position	Name	Address	Phone
President	~~Richard~~ Dick Adams	1234 East Maine	345 9807
Vice-President	Karen Webster	2 Indian Hill	890 7896
Corresponding Secretary	Virgina Walstrom	16 Green Street	~~890~~ 980 6743
Recording Secretary	Pat Ingersol	27 Olive Street	980 7865
Treasurer	Paul Oregon	11 Willow Lane	237 8973
Historian	William Robinson	12 Forest Lane	529 0921
Newsletter	Patricia ~~Olsen~~ Olsen	11 Wine Street	217 5444

PRINT A HARDCOPY OF THE ABOVE STATISTICAL TABLE AND THE DOCUMENT SUMMARY.

LAKE
COUNTY
AREA
VOCATIONAL
CENTER

COMPETENCY-BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

STUDENT LEARNING GUIDE

Produced By J Robinson Date 02/05/85

TASK: Print documents using the dual column feature on the Wang OIS 60 Information Processing System.

PURPOSE: The dual column feature on the Wang OIS 60 allows the operator to print text in two columns. The final printout looks similar to that found in printed textbooks. This feature may also be used for printing telephone lists, personnel lists, and address lists.

INFORMATION PROCESSING

Program	Task	Est.Time	Prereq.
SOO	170B12	5 hours	170B1 to 170B11

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME _____ SOCIAL SECURITY NUMBER _____

LENGTH OF CONTRACT (NORMAL TIME IN HOURS) _____

2. TERMINAL PERFORMANCE OBJECTIVE

Given the Wang OIS 60 Information Processing System, the needed data, and supplies, print text using the dual column feature.

To master this task, you must score 11 out of 13 on a written exam and 15 out of 15 on a product checklist.

2a. INTERMEDIATE OBJECTIVE(s)

1. Print documents using the dual column feature available on the Wang OIS 60 Information Processing System.

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____. I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

Student's Signature _____

Instructor's Signature (verifies competency) _____

INTERMEDIATE OBJECTIVE #1

Print documents using the dual column feature available on the Wang OIS 60 Information Processing System.

LEARNING STEPS (Activities)

1. To print text using the dual column feature, complete Resource #1.

2. To print text that is to be read continuously using the dual column feature, see Resource #2.

3. To keyboard text that is to be printed using dual column, complete Resource #3.

4. To align sections of dual column text horizontally, see Resource #4.

5. See Resource #5 to print stand-alone pages while using the dual column print feature for other pages.

6. To review, complete Resource #6A and #6B.

7. Complete Resource #7A and #7B to measure your ability to print text using the dual column feature on the Wang OIS 60 Information Processing System.

RESOURCES

1. Read pages 12-01 to 12-12 in WANG - DUAL COLUMN completing exercises as directed.

2. Read pages 12-13 to 12-17 in WANG - DUAL COLUMNS. Complete exercises as directed.

3. Complete exercise as directed on page 12-18 to 12-22 in WANG - DUAL COLUMN.

4. Read pages 12-23 to 12-25 in WANG - DUAL COLUMN completing exercises as directed.

5. Read pages 12-26 to 12-37 in WANG - DUAL COLUMN. Complete exercises as directed.

6A. Read Information Sheet 170.B.12 on guide pages 4 and 5.

6B. Complete skill building exercises on pages 12-43 to 12-51 in WANG - DUAL COLUMN.

7A. Product/Performance Checklist on guide pages 6 and 7.

7B. Criterion Exam 170.B.12.

DUAL COLUMN PRINTING
INFORMATION SHEET
170.B.12

The dual column printing feature on the Wang allows the operator to print such items as mailing lists, address lists, personnel lists in two separate columns. Text materials may also be printed in dual columns with each column justified.

The text that follows would appear in final printout as shown. However, when keyboarded each column would appear on a separate page.

John Jones Apt. 2C 5 Weidner Rd. Buffalo Grove, IL 60090	Alexis Lewis 12 Anderson Avenue Wheeling, IL 60090

Why would an operator want to put each column on a separate page? Editing the document would be much easier if columns were keyboarded on separate pages. If a line is added to one column in the sample above, you would be adding a line to the second column. When columns are keyboarded on separate pages, this does not happen.

Each column may be keyboarded in the same document with each on a separate page or it is possible to create each column in a separate document.

PRINTING DUAL COLUMN DATA

1. When the data has been keyboarded for each column, select SPECIAL PRINT FUNCTIONS from the main menu.

   The following choices will appear:

   - Cancel Print Request
   - Select Next Printed Document
   - Merge Print
   - Dual Column Print
   - Print Index

2. Select DUAL COLUMN PRINT by moving the acceptance block in front of that option.

3. Enter the ID number for the document to be printed after the prompt - PLEASE ENTER DOCUMENT ID:

4. If the text is stored in two different documents, enter the second identification number after the prompt - SECONDARY DOCUMENT ID:

5. Complete the PRINT DOCUMENT menu as follows.

   a. Enter the appropriate Character Set No. and Printer No.
   b. Enter the two left margins - one for each column.

      Use this formula to calculate the left margins for the columns.

TOTAL SPACES REQUIRED		Line length of Column 1
	+	Spaces to be left between columns
	+	Line length for Column 2
	=	Total spaces required
LEFT MARGIN FOR COLUMN 1		Total spaces available 85 or 102
	-	Total spaces required
	=	Total spaces for margins
	÷	2
LEFT MARGIN FOR COLUMN 2	=	Left margin for Column 1
	+	Line length of Column 1
	+	Spaces to be left between columns
	=	Left margin for Column 2

STAND-ALONE PAGES

If you choose to have a stand-alone page (a page that does not contain dual column text) printed in the middle of dual column text, follow these steps.

1. At the beginning of the stand-alone page

   Press SHIFT and MERGE then RETURN.

2. At the bottom of the stand-alone page, add a page break if one is not already there.

SOURCE: WANG LABORATORIES - DUAL COLUMN

PERFORMANCE/PRODUCT CHECKLIST

Program: SECRETARIAL OFFICE OCCUPATIONS/INFORMATION PROCESSING

Task No: 170.B.12

Student's Name: _____ Date Of Attempt: _____

Evaluator's Name: _____ Evaluation Site: _____

Performance Attempt: 1 2 3 4

Terminal Performance Objective:

Given the Wang OIS 60 Information Processing System, the needed data, and supplies, print text using the dual column feature.

To master this task, you must score 11 out of 13 on a written exam and 15 out of 15 on a product checklist.

Directions To The Student:

Before attempting this task for mastery, carefully review this checklist. You will be evaluated on the basis of this checklist. When you feel you are ready for evaluation, contact your instructor. You must complete your performance within 55 minutes and must score at least _____ out of _____ points or 100 % for mastery. Critical items are marked with an asterisk (*). These items must be satisfactorily completed.

Directions To The Evaluator:

The student will contact you when ready for the evaluation. The student must complete the performance within 55 minutes and must score _____ out of _____ points or _____ % and all items marked with an asterisk (*) must be satisfactorily completed.

PERFORMANCE/PRODUCT CHECKLIST

PART II

Yes	No		
___	___	1.	Each column must be 36 spaces in length.
___	___	2.	There must be 10 spaces between columns.
___	___	3.	There must be an equal left and right margin.
___	___	4.	There must be a 5-space tab indention.
___	___	5.	The title must be centered over both columns.
___	___	6.	There must be no errors in text.
___	___	7.	Both columns must be justified.
___	___	8.	Dual column must be used to print out the hard copy.

PART III

Yes	No		
___	___	1.	List of addresses is created using a 40 space line.
___	___	2.	Vertical spacing of 1 is used.
___	___	3.	All errors are corrected.
___	___	4.	Merge graphics are entered after each section of data.
___	___	5.	One blank line is left between sections.
___	___	6.	Sections on left line up with sections on right at the top.
___	___	7.	Left and right margins are even.

PROJECT SUMMARY SHEET

170.B.12

TRAINING DOCUMENTS

ADDRESS LIST _____

LET'S COMPARE _____

HORIZONTAL ALIGN _____

TELEPHONE LIST _____

NEW DOCUMENTS

DUAL COLUMN _____

SPECIAL DUAL COLUMN 1 _____

SPECIAL DUAL COLUMN 2 _____

BROCHURE _____

CRITERION EXAM 170.B.12

WRITTEN CRITERION EXAM - PART I	_____	_____	_____
DUAL COLUMN TEXT - PART II	_____	_____	_____
DUAL COLUMN LIST - PART III	_____	_____	_____

INFORMATION/WORD PROCESSING
SECRETARIAL OFFICE OCCUPATIONS
CRITERION EXAM

TASK 170.B.12

The purpose of this exam is to determine whether or not you have understood the information presented on dual column printing on a Wang OIS 60 Information Processing System.

Directions:

PART I

Write your answers in the space provided to the left of the question. Select the answer that best completes or defines the statement. A minimum score of 90 percent is required.

PART II

Keyboard the document as directed. Follow all instructions given for formatting the text. Correct any errors made. A maximum time of 40 minutes will be allowed to complete this part of the examination.

PART III

Keyboard the list of addresses as directed. All errors must be corrected. Follow all instructions given for formatting the text. A maximum time of 15 minutes will be allowed to complete this part of the examination.

DUAL-COLUMN FEATURE
Wang OIS 60 Word Processing
170.B.12

DIRECTIONS: Write the letter that comes before the correct answer on the the blank line.

____ 1. To print two columns (each column located in a separate document), you must select

a. Two Column Print
b. Multiple Column Print
c. Column Print
d. Dual Column Print

____ 2. If you attempt to edit two columns (both on the same screen) by adding a line to the left column, the second column

a. will have a line added to it also.
b. will have a line deleted from it.
c. will drop down one line.
d. both a and c.

____ 3. Margins for both the left and right column are set on the _____ menu.

a. Special Print Functions
b. Print Document
c. Dual Column
d. Two Column Print

____ 4. To calculate the left margin for the right-hand column, add the following.

a. Left margin for left-hand column and the line length of the left-hand column
b. Left margin for left-hand column and the desired space between
c. Left margin for left-hand column and the right margin for the right-hand column
d. None of the above

____ 5. The left margin for the left-hand column of a dual column print would be _____ if the left column longest line is 20, the right column longest line is 30, and 10 spaces are to be left between columns. The document will be printed using a 12-pitch print wheel.

a. 013
b. 021
c. 027
d. None of the above

___ 6. The left margin for the right-hand column in #5 would be

a. 061
b. 051
c. 043
d. None of the above

___ 7. When you are printing dual columns, the line spacing is determined by the vertical line spacing set in the

a. format line set in the print document menu.
b. format line set in the left column.
c. format line set in the right column.
d. format line set with the lowest numbered document ID.

___ 8. If you have text stored in two separate documents and are printing out dual columns, the right column

a. should be longer than the left.
b. should not be longer than the left.
c. can either be longer or shorter - it makes no difference.
d. None of the above.

___ 9. If you create one document for printing text, the printer starts a new page after reading two page breaks (one for each column) thus

a. it makes no difference whether one column is longer than the other.
b. the columns must be the same length.
c. the left column must always be longer than the right.
d. None of the above.

___ 10. To align sections of text in dual column printing, you should press _____ after each section.

a. PAGE
b. SHIFT + PAGE
c. COMMAND + PAGE
d. None of the above.

___ 11. To create a stand-alone page when printing dual columns (All text is stored in the same document.), you must depress _____ before the stand-alone page and _____ after the stand-alone page.

a. PAGE, SHIFT and MERGE
b. COMMAND and PAGE, MERGE
c. SHIFT and MERGE, PAGE
d. None of the above

____ 12. If you are using two documents to store text for dual column print, you create stand-alone pages by pressing _____ at the bottom of the right-hand column that precedes the stand-alone page.

a. MERGE and then COMMAND
b. MERGE and then RETURN
c. MERGE and then SHIFT
d. None of the above

____ 13. If you are using two documents to store text for dual column printing, you end the stand-alone page by pressing _____ and _____.

a. MERGE and RETURN
b. MERGE and then COMMAND
c. MERGE and then SHIFT
d. None of the above

PART II

DIRECTIONS: Type the text that appears on the page that follows. Correct any errors you make while keyboarding.

- Create both pages in the same document.
- Set the linespace for 36 with a tab at 5.
- Leave 10 spaces between the columns.
- Center the title over both columns.
- Justify each column.
- Text must have an equal left and right margin when printed.
- Use dual column to print out a hard copy of text.

COMPUSERVE FOR COLLEGE-BOUND → Center

Making the decision about which college to attend can be difficult, but the Consumer Information Service can offer invaluable assistance to high-school students and their parents through two online services, The College Board and The College Press Service.

The College Board (GOTCB at the ! prompt) is operated by the College Entrance Examination Board, the same organization that administers the Scholastic Aptitude Test (SAT) required for admission to most colleges and universities.

Does special preparation for the college board examination help students increase their scores? The publishers of the tests tackle this frequently asked question and offer six specific points students should consider when preparing for the SAT. In addition, the Advanced Placement program, which allows secondary-school students to complete college level courses for college credit while still in high school, is thoroughly explained. There is also a valuable listing of important dates, so students will be sure to complete necessary admission deadlines.

Before deciding where all that tuition money will be spent, students and parents need a plan. Under the college planning section, they will receive hints on how not to choose a college, and look at some of the myths surrounding college selection and admission. For instance, is there only one college that will satisfy all of a student's needs, or are all colleges really the same?

Adults who are considering returning to college would do well to review the section on Adult Education in The College Board. In addition, to an overview of learning alternatives for adults, the section addresses the 10 most common fears of adults who are considering returning to school.

The College Board also offers detailed, easy-to-understand explanations of the complicated and ever-increasing financial aid programs now available to college students. And for those who want more information, a listing of college-planning publications is presented.

Current news and information about a number of specific colleges and universities are available from The College Press Service (GO CPS). Launched as a national college news service for collegiate publications, CPS has played an important part in keeping students and parents informed of campus events and trends, as well as specific admission and recruitment policies, federal and state legislation, financial aid information, court decisions, classroom trends, funding patterns, and student goings-on.

Updated weekly, The College Press Service presents concise bulletins under Campus News Briefs or news stories under Campus News in Depth.

With the start of the school year in September, CPS will offer online National Campus Classifieds, where individuals may post notices, advertisements or messages of 50 words or less for as little as $9 a week. (This is the high-tech way to catch a ride home for Thanksgiving!)

So before writing away for hundreds of college catalogs or raiding the local bookstore for SAT preparation guides, enlist CompuServe to help make one of the biggest decisions of a lifetime a little easier.

SOURCE: ONLINE TODAY, August, 1984.

PART III

DIRECTIONS: Create a new document.

Keyboard the list of addresses that follows. Correct any errors you make while keyboarding. After each section of text, enter a merge graphic. Press return after each merge graphic so that you will have a blank line between secions.

Use a linespace of 40; no tabs are needed. Set vertical spacing at 1.

Eugene Strunk
227 N. Missouri
Morton, IL 61550

Andrew Parker
Apt. 3
416 Chamberlain
South Bend, IN 46615

Jim Danenhauer
5425 N. Depew St.
Arvada, CO 80002

J. E. Falkner
1733 N. Utah Avenue
Oklahoma City, OK 73107

PART III-Continued

DIRECTIONS: Create a new document.

Keyboard the list of addresses that follows. Correct any errors you make while keyboarding. After each section of text, enter a merge graphic. Press return after each merge graphic so that you will have a blank line between secions.

Use a linespace of 40; no tabs are needed. Set vertical spacing at 1.

R. A. Anderson
Apt. 6
200 Elm Street
Leominister, MA 01453

Wm Skelly
45 Holly Road
Coatesville, PA 19320

Maurice Milleville
11200 Lindale
St. Ann, MO 65449

Steve Reed
Herod, IL 62947

PART III-Continued

DIRECTIONS: Return to the word processing menu. Select special print functions. Using dual column, print a hard copy of the list of addresses.

Set the left margin for 7 for Column 1 and the left margin for 55 for Column 2. Use a 12-pitch print wheel.

Instructor must observe as data is printed in dual columns.

LAKE
COUNTY
AREA
VOCATIONAL
CENTER

COMPETENCY-BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

STUDENT LEARNING GUIDE

Produced By J Robinson Date 02/11/85

TASK: Merge two documents on the Wang OIS 60

PURPOSE: The merge print feature on the Wang OIS 60 enables the operator to merge a form letter with a list of variables so that letters may be personalized. These documents are merged at the printer and are not stored on disk in their final form.

INFORMATION PROCESSING

Program	Task	Est.Time	Prereq.
SOO	170B13	6-10 hrs.	170B1 to 170B12

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME _____ SOCIAL SECURITY NUMBER _____

LENGTH OF CONTRACT (NORMAL TIME IN HOURS) _____

2. TERMINAL PERFORMANCE OBJECTIVE

Given a Wang OIS 60 workstation, the needed data, and supplies, merge a primary and a secondary document to printer.

To master this task, you must score 11 out of 12 on a written exam and score 9 out of 9 on a product checklist.

2a. INTERMEDIATE OBJECTIVE(s)

1. Merge a primary and a secondary document on the Wang OIS 60.

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____. I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

Student's Signature _____

Instructor's Signature (verifies competency) _____

INTERMEDIATE OBJECTIVE #1

Merge a primary and a secondary document on the Wang OIS 60.

LEARNING STEPS (Activities)

1. See Resource #1 to learn how to create the primary document and to gain practice in creating the primary document.
2. Complete Resource #2 to create the secondary document.
3. To merge a letter with a list of variables, see Resource #3.
4. To make sets of variable data easier to read, complete Resource #4.
5. To merge a form envelope with a list of variables, read and complete Resource #5.
6. To gain additional skill in merging data, complete Resource #6.
7. To review, complete Resource #7A and #7B.
8. To measure your ability to merge a primary and a secondary document, complete Resources #8A and 8B.

RESOURCES

1. Read pages 13-3 to 13-5 in WANG - MERGE PRINT. Complete the exercise as directed.
2. Read pages 13-6 to 13-9 in WANG - MERGE PRINT completing the exercises as directed.
3. Read pages 13-10 to 13-11 in WANG - MERGE PRINT. Complete exercise as directed on page 13-12 in MERGE PRINT.
4. Read page 13-13 to 13-14 in WANG - MERGE PRINT.
5. Read page 13-15 in WANG - MERGE PRINT completing the exercise as directed.
6. Complete exercise as directed on page 13-16 to 13-20 in WANG - MERGE PRINT.

7A. Read pages 13-21 to 13-23 in WANG - MERGE PRINT. Read pages 4 to 8 in this guide.

7B. Complete skill building exercises on page 13-24 to 13-33 in MERGE PRINT.

8A. Read the Product/Performance Checklist found on pages 9 and 10 in this guide.

8B. Complete Criterion Exam 170.B.13.

INFORMATION SHEET #1

MERGE PRINT
170.B.13

The merge print feature allows the operator to merge a letter (primary document) with a list of variables at the printer. The merged document is not stored on disk during this process.

A sample primary document follows.

November 10, 198-

↕ ---------- MERGE CODE

Dear ↕:

Thank you for your recent request for our ↕ catalog. The catalog you requested has been mailed to you.

We look forward to receiving your first order, ↕.

Sincerely,

John Smith
Director of Sales

Variable data follows. This data will be inserted in sequence at the MERGE codes.

Mr. John Adams
49 South Lindenberry Avenue
Grayslake, IL 60030 Mr. Adams Christmas John

CREATING A PRIMARY DOCUMENT

Follow these steps when creating a primary document.

- Create a new document.
- Keyboard the form letter.
- Press MERGE in the primary document where variable data is to be entered.

November 10, 198-

↕

Dear ↕:

- Press CANCEL and EXECUTE to return to the word processing menu.

CREATING THE SECONDARY DOCUMENT

Follow these steps when creating the secondary document.

- Create a new document.
- Keyboard the variable data.
- End each variable entry by pressing MERGE.
- End each set of variable entries by pressing SHIFT + MERGE.

Mr. John Adams
49 South Lindenberry Avenue
Grayslake, IL 60030↕Mr. Adams↕Christmas↕John↕Ms. Alice Johnson
33 East Weidner Drive
Wheeling, IL 60090↕Ms. Johnson↕Christmas↕Alice↕

SHIFT + MERGE CODES

- Press CANCEL then EXECUTE to return to the word processing menu.

Follow these steps to merge and print the final document.

- Select Special Print Functions from the Word Processing Menu.
- Enter the Primary Document ID No.
- Enter the Secondary Document ID No.
- Complete the Print Document Menu that is displayed on the screen.
- Press EXECUTE.

MAKING VARIABLES EASIER TO READ

It will be much easier to read your list of variable data if you insert carriage returns at the end of each set of variables.

- Insert an extra MERGE GRAPHIC at the beginning of the primary document.

↕
November 10, 198-

↕
Dear↕:

Thank you for your recent request for our ↕catalog.

- Insert two RETURNS and a MERGE GRAPHIC at the beginning of each set of variables.

◀
◀
↕Mr. John Adams◀
49 South Lindenberry Avenue◀
Grayslake, IL 60030↕Mr. Adams↕Christmas↕John↕◀
◀
↕Ms. Alice Johnson◀
33 East Weidner Drive◀
Wheeling, IL 60090↕Ms. Johnson↕Christmas↕Alice↕◀
◀

A sample merged letter follows.

November 10, 198-

VARIABLE DATA

Mr. John Adams
49 South Lindenberry Avenue
Gravslake, IL 60030

Dear Mr. Adams:

Thank you for your recent request for our Christmas catalog. The catalog you requested has been mailed to you.

We look forward to receiving your first order, John.

Sincerely,

John Smith
Director of Sales

PRINTING ENVELOPES FOR MERGED DOCUMENTS

Envelopes may be printed for each merged document.

Follow these steps to create the primary document for the envelope.

- Create a new document and type a don't merge graphic for each set of variables you do not want to print and a merge graphic for each variable you do want to print.
- Press CANCEL and EXECUTE to return to the word processing menu.

Follow these steps to merge and print the envelopes.

- Select Special Print Functions from the Word Processing Menu.
- Enter the Primary Document ID No. you created for the envelopes.
- Enter the Secondary Document ID No.
- Complete the Print Document Menu that is displayed on the screen.
- Press EXECUTE.

On the WANG OIS 60 INFORMATION PROCESSING SYSTEM, merge print is the least sophisticated merge feature. Merging can be accomplished through Advanced Function and also through List Processing.

SOURCE: WANG LABORATORIES - MERGE PRINT

PERFORMANCE/PRODUCT CHECKLIST

Program: SECRETARIAL OFFICE OCCUPATIONS/INFORMATION PROCESSING

Task No: 170.B.13

Student's Name: _____ Date Of Attempt: _____

Evaluator's Name: _____ Evaluation Site: _____

Performance Attempt: 1 2 3 4

Terminal Performance Objective:

Given the Wang OIS 60 Information Processing System, the needed data, and supplies, merge a primary and a secondary document to printer.

To master this task, you must score 11 out of 12 on a written exam and score 9 out of 9 on a product checklist.

Directions To The Student:

Before attempting this task for mastery, carefully review this checklist. You will be evaluated on the basis of this checklist. When you feel you are ready for evaluation, contact your instructor. You must complete your performance within 50 minutes and must score at least _____ out of _____ points or 100 % for mastery. Critical items are marked with an asterisk (*). These items must be satisfactorily completed.

Directions To The Evaluator:

The student will contact you when ready for the evaluation. The student must complete the performance within 50 minutes and must score _____ out of _____ points or 100 % and all items marked with an asterisk (*) must be satisfactorily completed.

PERFORMANCE/PRODUCT CHECKLIST

Yes	No	
____	____	Letter and variables contain no keyboarding errors.
____	____	Block style is used.
____	____	Paragraphs are blocked.
____	____	Single paragraph is block indented as shown.
____	____	Open punctuation is used.
____	____	Left and right margins are even.
____	____	Spacing between letter parts is correct as shown on test.
____	____	Letter merged correctly with listing of variables.
____	____	Envelopes are printed (following standard formatting rules) using the merge feature.

PROJECT SUMMARY SHEET

MERGE PRINT TRAINING MANUAL

The following documents should be handed in your instructor prior to taking the post test.

_____ Public Relations Letter

_____ Tony Cartone
_____ Elizabeth Lockhead

_____ Public Relations Envelopes

_____ Tony Cartone
_____ Elizabeth Lockhead

_____ Primary Merge Print

_____ Judy Smith
_____ Janet Snowden
_____ Betty Armstrong

_____ Letter

_____ Francis Palmer
_____ James Mosher
_____ Julie Norris

_____ Envelope

_____ Francis Palmer
_____ James Mosher
_____ Julie Norris

CRITERION EXAM

_____ Written Exam (90 percent required)

_____ PART II - MERGED LETTER (100 percent accuracy required)

_____ PART III - MERGED ENVELOPES (100 percent accuracy required)

NAME _____ DATE _____

FINAL SCORE _____

INFORMATION PROCESSING
SECRETARIAL OFFICE OCCUPATIONS
CRITERION EXAM
170.B.13

The purpose of this exam is to determine whether or not you have understood the procedures for MERGING TEXT on a Wang OIS 60 Information Processing System.

DIRECTIONS:

Written Exam

Write answers as directed on Part I of this test. A minimum score of 90 percent (11 answers correct) is required to pass this part of the exam.

Performance

PART II

Keyboard the PRIMARY AND SECONDARY documents as directed in Part II of this exam. Merge the primary and secondary documents using the special print functions menu. All errors must be corrected.

Your instructor must observe as you merge the primary and secondary documents. TIME ALLOWED: 30 minutes.

PART III

Create a PRIMARY DOCUMENT for the envelope. Enter MERGE AND DON'T MERGE CODES as directed in your training manual. Merge the PRIMARY DOCUMENT for the envelopes with the variables list created in Part II.

Instructor must observe as documents merge and print. TIME ALLOWED: 20 minutes.

INFORMATION/WORD PROCESSING
SECRETARIAL OFFICE OCCUPATIONS
MERGE PRINT
170.B.13

DIRECTIONS: Write your answer on the blank provided to the left of the question. Select the letter that comes before the answer that best completes or defines the statements.

____ 1. Merge print allows you to

a. personalize standard letters.
b. merge standard text with variables.
c. both a and b.
d. none of the above.

____ 2. The ———— document contains the standard text.

a. essential
b. primary
c. alternate
d. critical

____ 3. The operator types a ——— graphic at each position in the document that contains standard text where she/he wants the printer to print variable information.

a. ↑
b. →
c. ↕
d. ↕

____ 4. The ————— document contains the variable text.

a. primary
b. alternate
c. secondary
d. nonessential

____ 5. Each variable entry should end with a ——— graphic.

a. ↕
b. ↕
c. →
d. ↔

____ 6. For each letter you want to create you must type one set of ———— entries.

a. standard
b. essential
c. fixed
d. variable

____ 7. A merge safeguard should be used to end each set of variable entries. The merge safeguard graphics is the ————.

a. ↕
b. ↕
c. →
d. ↔

____ 8. After the standard and variable text have been recorded, you select the ———— menu to merge print.

a. Special Print Functions
b. Print Document
c. Utilities
d. Document Index

____ 9. To make sets of variable entries easier to read, you can separate each set of variables with a

a. merge graphic.
b. shift and merge graphic.
c. command and return graphic.
d. return graphic.

____ 10. To print an address on an envelope for each letter merged, you can use the same ———— entries you created to print the letters.

a. primary
b. mixed
c. standard
d. variable

____ 11. To print an envelope, you create a new document and type a ———————— graphic for each variable entry you <u>do not want</u> to print on the envelope.

a. ⇕
b. ◀
c. ↕
d. |→

____ 12. To print an envelope, you create a new document and type a ———————— graphic for each variable entry you <u>do want</u> to print on the envelope.

a. ◀
b. ⇕
c. →
d. ↕

PART II

DIRECTIONS: Create a new document - a primary document. Type the letter that appears on the following page. Use MERGE CODES for the address and the salutation. Correct any errors you make while keyboarding the letter.

Create a secondary document. Keyboard the list of variables that follow the letter use MERGE AND DON'T MERGE GRAPHICS as recommended in your MERGE PRINT training manual.

Use the MERGE PRINT feature to merge and print letters to each individual on the variable list.

Instructor must observe as you merge and print the first document.

Today's Date

_____
_____
_____
_____

Dear _____

Many of you have asked if we could raise the face amount of life insurance available through our group plan.

> I am pleased to report we have secured permission from the insurer to double the previous maximum -- from $120,000 up to $240,000 -- and without increasing the premium per $1,000 coverage.

I think you will agree that the new $240,000 maximum brings our protection in line with the needs of many members whose costs of living and expanded lifestyle can now be served.

If your present insurance estate has not kept pace with the anticipated living costs of your family, now is your opportunity to apply for whatever additional coverage you need.

This competitive, economical life insurance plan is offered as a service to our members without cost or benefit to your Association.

I urge you to read carefully full details in the enclosed brochure. In our opinion, this plan clearly reflects the advantages of developing protection exclusively for the career needs of educators and their families.

We believe that you, too, may find that our plan meets your needs. If you and your family feel you'd be more comfortable accepting this invitation, simply complete the request form and return it to our Administrator in the envelope provided.

Sincerely

NATIONAL BUSINESS EDUCATION ASSOCIATION

Executive Director

XX

Enclosure

SOURCE: NATIONAL BUSINESS EDUCATION ASSOCIATION

VARIABLE DATA

Mr. Samuel Maura
63 Indian Hill
Arlington Heights, IL 60004

Mr. Dick Davenport
12 White Pine
Wheeling, Illinois 60090

Mr. Paul Smith
3 Palm Court
Grayslake, IL 60030

Ms. Irene Overton
Apt. 34
41 Winchester Lane
Mackinaw, IL 61755

Miss Tabitha Weiss
Apt. 10
Carriage House Lane
Waukegan, IL 60085

PART III

DIRECTIONS: Create a new document - a primary document for the envelope. Type the necessary MERGE and SHIFT + MERGE codes to print out the name and address on an envelope.

Use the MERGE PRINT feature to merge and print an envelope for each individual on the variable list.

Instructor must observe as you merge and print the first document.

LAKE
COUNTY
AREA
VOCATIONAL
CENTER

COMPETENCY-BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

STUDENT LEARNING GUIDE

Produced By J Robinson Date 02/11/85

TASK: Sort data on the Wang OIS 60 Information Processing System

PURPOSE: Fields of like data my be sorted in either ascending or descending order. Data may be placed in alphabetical or numerical order depending upon the type of data located in a particular field. This feature is often used for alphabetizing lists that change frequently such as telephone lists, customer lists, and personnel lists.

INFORMATION PROCESSING

Program	Task	Est.Time	Prereq.
SOO	170B14	2-4 hrs.	170.B.1 170.B.14

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME _____ SOCIAL SECURITY NUMBER _____

LENGTH OF CONTRACT (NORMAL TIME IN HOURS) _____

2. TERMINAL PERFORMANCE OBJECTIVE

Given a Wang workstation, the needed data, and supplies, sort text in ascending and descending order.

To master this task, you must score 15 out of 15 on a product checklist and score 15 out of 17 on a written exam.

2a. INTERMEDIATE OBJECTIVE(s)

1. Sort data on the Wang OIS 60 Information Processing System.

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____. I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

Student's Signature _____

Instructor's Signature (verifies competency) _____

INTERMEDIATE OBJECTIVE #1

Sort data on the Wang OIS 60 Information Processing System.

LEARNING STEPS (Activities)

1. To sort text that has been previously keyboarded, see Resource #1.
2. To define terms related to sorting text, read Resource #2.
3. To prepare text to be sorted, complete Resource #3.
4. Complete Resource #4 to sort text containing blank fields.
5. See Resource #5 to tab fields correctly that are to be sorted.
6. To type columnar headings when text is to be sorted, see Resource #6.
7. See Resource #7 to sort numeric data.
8. To sort more than one field of data, see Resource #8.
9. To review, complete Resource #9A and #9B.
10. To measure your ability to sort data on the Wang OIS 60, complete Resource #10A and 10B.

RESOURCES

1. Read instructions and complete exercises as directed on pages 14-3 to 14-5 in WANG - SORTING TEXT.
2. Read pages 14-5 to 14-7 in WANG - SORTING TEXT.
3. Read page 14-8 in WANG - SORTING TEXT completing exercise as instructed.
4. Read pages 14-9 to 14-10 in WANG - SORTING TEXT. Complete exercise as directed.
5. Read pages 14-11 to 14-15 in WANG - SORTING TEXT. Complete exercise as instructed.
6. Read page 14-16 to 14-17 in WANG - SORTING TEXT completing exercises as directed.
7. Read pages 14-17 to 18 in WANG - SORTING TEXT completing exercise as directed.
8. Read instructions and complete all exercises on pages 14-18 to 14-21 in WANG - SORTING TEXT.

9A. Read Information Sheet #1 on guide pages 4 and 5.

9B. Complete skill building exercise on pages 14-23 to 14-25 in SORTING TE

10A. Read Product/Performance Checklist on guide pages 6 and 7.

10B. Complete Criterion Exam 170.B.14.

SORTING TEXT
170.B.14
INFORMATION SHEET #1

Lists of alphabetic or numeric data may be sorted in ascending or descending order on the WANG OIS 60 Information Processing System.

Data that is to be sorted must be keyboarded in the following manner:

1. Fields of data to be sorted should be separated by a single tab stop.

2. A return graphic should end each record.

3. No title should appear on the page of text to be sorted.

All the text in a single document to be sorted is called a <u>file</u>. A sample data file follows:

Broderick, Jon	Human Resources)	
Cima, Colleen	Accounting)	
Doyle, Darlene	Information Services)	——File
Gold, Gerry	Transportation)	
Lee, Larry	Sales)	

All the information pertaining to one individual is known as a <u>record</u>. All the information about Colleen Cima is a record.

Cima, Colleen Accounting———Record

A field is a piece of like data within a record. A field from the above record would be either the name of the individual - Colleen Cima or the department she works in - Accounting.

Cima, Colleen Accounting ——Field

After all the information in a document has been keyboarded, the operator moves the cursor to the first position in the column of text to be sorted. She/he then

1. presses COMMAND, MERGE then EXECUTE.

Text in that field will then be sorted in ascending order - from lowest to highest.

To sort text in descending order - from highest to lowest - the operator, positions the cursor under the first character in the field to be sorted. The operator then

1. presses COMMAND, SHIFT + MERGE, then EXECUTE.

If several fields of data are to be sorted on the same document, the operator should sort the least important field first and the most important field last. For example, it is most important in a particular project that the departments be in alphabetical order. The department field ~~would~~ be sorted last.

The maximum amount of text that can be sorted is 256 screens or 4,830 lines. This text must all be on one page.

SOURCE: WANG LABORATORIES - SORTING TEXT

PERFORMANCE/PRODUCT CHECKLIST

Program: SECRETARIAL OFFICE OCCUPATIONS/INFORMATION PROCESSING

Task No: 170.B.14

Student's Name: _____ Date Of Attempt: _____

Evaluator's Name: _____ Evaluation Site: _____

Performance Attempt: 1 2 3 4

Terminal Performance Objective:

Given a Wang workstation, the needed data, and supplies, sort text in ascending and descending order.

To master this task, you must score 15 out of 15 on a product checklist and score 15 out of 17 on a written exam.

Directions To The Student:

Before attempting this task for mastery, carefully review this checklist. You will be evaluated on the basis of this checklist. When you feel you are ready for evaluation, contact your instructor. You must complete your performance within 45 minutes and must score at least _____ out of _____ points or 100 % for mastery. Critical items are marked with an asterisk (*). These items must be satisfactorily completed.

Directions To The Evaluator:

The student will contact you when ready for the evaluation. The student must complete the performance within 45 minutes and must score _____ out of _____ points or 100 % and all items marked with an asterisk (*) must be satisfactorily completed.

PERFORMANCE/PRODUCT CHECKLIST

EXAM

_____ PART I (90 percent required)

_____ PART II

Yes	No	
_____	_____	Keyboarded with no errors.
_____	_____	Title and column headings printed.
_____	_____	Margins even on printout.
_____	_____	A minimum of six spaces should appear between columns.
_____	_____	Department field must be in alphabetical order.

_____ PART III

Yes	No	
_____	_____	Text keyboarded with no errors.
_____	_____	Title and column headings printed.
_____	_____	Margins even on printout.
_____	_____	A minimum of six spaces should appear between columns.
_____	_____	Employee field must be in alphabetical order.

_____ PART IV

Yes	No	
_____	_____	Text keyboarded with no errors.
_____	_____	Title and column headings printed.
_____	_____	Margins even on printout.
_____	_____	A minimum of six spaces should appear between columns.
_____	_____	Extension field must be in descending order.

PROJECT SUMMARY SHEET

TRAINING DOCUMENTS

TRY SORTING TEXT _____

OCCUPATIONS _____

SIX PLACES _____

REQUEST FOR PERSONNEL _____

NEW DOCUMENTS

PRODUCE ORDER _____

PERSONNEL RECORDS _____

CRITERION EXAM

WRITTEN EXAM	_____	_____	_____
PART II	_____	_____	_____
PART III	_____	_____	_____
PART IV	_____	_____	_____

NAME _____ DATE _____

POINTS _____

INFORMATION/WORD PROCESSING
SECRETARIAL OFFICE OCCUPATIONS
CRITERION EXAM

TASK 170.B.14

The purpose of this exam is to determine whether or not you have understood the information presented on sorting text on a Wang OIS 60 Information Processing System.

WRITTEN EXAM

PART I

Write your answers in the space provided to the left of the question. Select the answer that best completes or defines the statement. A minimum score of 90 percent is required.

PERFORMANCE EXAM

A minimum score of 100 percent is required for this portion of the exam.

PART II

Keyboard the document as directed. Follow all instructions given for formatting the text. Correct any errors made. A maximum time of 25 minutes will be allowed to complete this part of the examination.

PART III

Keyboard the list of additional telephone numbers as directed. All errors must be corrected. Follow all instructions given for formatting the text. Sort as directed. A maximum time of 15 minutes will be allowed to complete this part of the examination.

PART IV

Sort as directed. A maximum of 5 minutes will be allowed to complete this part of the examination.

EVALUATION SHEET

INFORMATION/WORD PROCESSING
SECRETARIAL OFFICE OCCUPATIONS
SORTING TEXT
170.B.14

DIRECTIONS: Write your answer on the blank provided to the left of the questions. Select the letter that comes before the answers that best completes or defines the statement.

_____ 1. To arrange long lists of names and addresses in alphabetical order, you can use the ———— feature on the Wang OIS 60.

a. Merge
b. Don't Merge
c. Alphabetize
d. Sort

_____ 2. Ascending order places the list in what form?

a. Lowest to highest
b. Highest to lowest
c. Right to left
d. Left to right

_____ 3. To sort text in ascending order, you position the cursor under the first character of the column (field) you wish to sort and press

a. COMMAND, SORT, EXECUTE
b. EXECUTE, COMMAND, SORT
c. MERGE, COMMAND, EXECUTE
d. COMMAND, MERGE, EXECUTE

_____ 4. To sort text in descending order, position the cursor under the first character in the field you wish to sort and press

a. COMMAND, SHIFT + MERGE, EXECUTE
b. EXECUTE, COMMAND, SORT
c. MERGE, COMMAND, EXECUTE
d. COMMAND, MERGE, EXECUTE

_____ 5. A record consists of ———— set(s) of information.

a. one
b. two
c. five
d. ten

EVALUATION SHEET

_____ 6. A field is a ———— of information within a record.

a. group
b. set
c. large amount
d. single piece

_____ 7. The ——— field is the field you want to arrange in a particular order.

a. ideal
b. perfect
c. key
d. original

_____ 8. If you sort a field that contains blank lines in the key field, all the records with blank lines will appear ——— of the sort list.

a. at the end
b. at the beginning
c. in the middle
d. none of the above

_____ 9. Fields of data must be separated by ——— tab graphic(s).

a. one
b. two
c. three
d. no

_____ 10. Each record in a document that is to be sorted must end with a ——— graphic.

a. ▶
b. •
c. —•
d. ◀

_____ 11. The maximum of ——— lines may be sorted on the OIS 60 Information Processing System.

a. 3960
b. 4000
c. 4800
d. 4830

EVALUATION SHEET

_____ 12. If you fail to press ——— after the last record on the page of a document that is to be sorted, the system cannot sort the file.

a. ◀
b. •
c. ◆
d. ▶

_____ 13. Titles and column headings on documents that must be sorted should be typed ——————————————————.

a. before text is sorted
b. after text is sorted
c. while text is being sorted
d. none of the above

_____ 14. The maximum number of digits to the right of the decimal point that the system can sort is ————————.

a. one
b. two
c. four
d. six

_____ 15. If you want to sort more than one field of information, the most significant field is sorted ——————————————.

a. first
b. second
c. third
d. last

_____ 16. A file that is to be sorted must not be longer than ——— page(s).

a. one
b. two
c. three
d. five

_____ 17. A file that is to be sorted must be typed so that a ———— graphic separates each field.

a. ▶
b. •
c. ◆
d. ◀

EVALUATION SHEET

PART II

DIRECTIONS: Keyboard the telephone list that follows. Leave a minimum of six spaces between columns. Correct any errors that you make. Alphabetize the list; the department is the most significant field. Include the titles in the final printout. A triple space should follow the main title "TELEPHONE LIST UNION ELECTRIC."

Left and right margins should be even when printed. PRINT BOTH THE DOCUMENT AND THE DOCUMENT SUMMARY.

TELEPHONE LIST
UNION ELECTRIC

Employee	Department	Extension
Yoon, Melanie	Accounting	4920
Wiemerslage, Heide	Human Resources	0490
Yacktman, Steve	Sales	0491
Doule, Colleen	Information Services	3260
Broderick, Brad	Maintenance	0611
Begel, William	Human Resources	2349
Anfuso, Peter	Sales	0100
Freeman, Jason	Marketing	6034
Lee, Scott	Research	6000
Greenburg, Steven	Sales	3419
Sanders, Jean	Information Services	1411

EVALUATION SHEET

PART III

DIRECTIONS: Add the names that follow to the telephone list that you created in PART II. Correct any errors you make while keyboarding. Sort the Employee field as most significant. Place in ascending order.

Instructor must observe as you perform the sort operation.

Titles must be included in final printout - margins must be even.

PRINT THE DOCUMENT AND THE DOCUMENT SUMMARY.

Employee	Department	Extension
Linn, Duane	Sales	0461
Sanders, Jean	Accounting	1411
Pinsker, Don	Information Services	1900
Rosenthal, Mark	Accounting	2603

EVALUATION SHEET

PART IV

DIRECTIONS: Sort the list you completed in PART III with the Extension as the most significant field. Sort in descending order. PRINT A HARD COPY AND THE DOCUMENT SUMMARY. Titles should be included. Margins must be even on final printout.

APPENDIX V

CLC/LCAVC Joint Resolution

College of Lake County/Lake County
Area Vocational Center

JOINT RESOLUTION

WHEREAS the College of Lake County and the Lake County Area Vocational Center over the past years have developed a model working relationship; and

WHEREAS they have cooperated in using facilities, purchasing equipment and articulating their programs; and

WHEREAS it is important that this relationship continue to improve and flourish and that the College of Lake County and Lake County Area Vocational Center continue to strive to more effectively and efficiently serve the needs of the Lake County community and explore avenues to insure that the taxpayers of Lake County derive the maximum benefits from their tax dollars;

THEREFORE in order to carry on this mutually beneficial effort, be it resolved that the College of Lake County and the Lake County Area Vocational Center will:

explore additional use of both the College of Lake County and Lake County Area Vocational Center facilities in an attempt to maximize facility utilization;

continue to enhance program articulation efforts to assure a smooth flow of students between secondary and post-secondary experiences;

investigate expansion of programs available to and articulated between the institutions; and

investigate, analyze, and evaluate the potential for the College of Lake County becoming the administrative agent for the Lake County Area Vocational Center.

LAKE COUNTY AREA VOCATIONAL CENTER,
BOARD OF CONTROL

BY: _____
Chairman

ATTEST:

_____
Secretary

BOARD OF TRUSTEES, COLLEGE OF LAKE COUNTY

BY: _____
President

ATTEST:

_____
Secretary

APPENDIX VI

Certificate of Completion

GRANT COMMUNITY HIGH SCHOOL

GCHS

Certificate of Completion

This is to certify that _____

has achieved a satisfactory level of performance for the competencies indicated on the back of this certificate in the _____ program.

This instruction has been provided by the Grant Community High School in the County of Lake and approved by the State of Illinois, Department of Adult, Vocational and Technical Education.

Credit Earned _____

Hours of Instruction _____

Grade _____

_____ _____

Date of Completion Instructor

_____ _____

Principal Vocational Director

Certificate of Competencies

Student's Name _____ Program _____ Semester & Year _____

While in attendance, the student named has demonstrated skills in the proficiencies marked below:

MACHINE SHOP

ENGINE LATHE

- _____ Understands Lathe Parts & Functions
- _____ Sets Up Tools Properly
- _____ Drill & Tap
- _____ Bore & Ream
- _____ Cuts External Threads
- _____ Cuts Internal Threads
- _____ Cuts Taper, Compound Rest, Tail Stock & Taper Attachment
- _____ Uses Tool Post Grinder
- _____ Cuts Knurl
- _____ Uses Three Jaw, Four Jaw Chuck & Collet Attachment
- _____ Uses Faceplate
- _____ Turns to Project Specs
- _____ Selects Proper Feeds & Speeds

VERTICAL MILL

- _____ Understands Mill Parts & Functions
- _____ Indicates Head & Vise
- _____ Set-up Procedures
- _____ Uses Edge Finder
- _____ Uses Various Milling Cutters
- _____ Uses Fly Cutter
- _____ Uses Saw Blade
- _____ Cuts Gears
- _____ Uses Boring Head
- _____ Uses Jig Grinding
- _____ Uses Rotary Table
- _____ Uses Indexing Head
- _____ Uses Universal Vise
- _____ Drills, Taps, Reams & Counterdrills
- _____ Machines to Project Specs

HORIZONTAL MILL

Understands:

- _____ Mill Parts & Functions
- _____ Mill Safety
- _____ Set-up Procedures

Operates:

- _____ Horizontal Mill

Performs:

- _____ Plain Milling
- _____ Gang Milling
- _____ Side Milling
- _____ End Milling
- _____ Gear Cutting
- _____ Machines Project to Specs

SURFACE GRINDER

- _____ Understands Grinder Parts & Functions
- _____ Uses Grinder Safety
- _____ Understands Wheel Characteristics
- _____ Selects Proper Wheels
- _____ Dresses Wheels
- _____ Uses Magnetic Chuck Properly
- _____ Performs Flat Grinding
- _____ Grinds Angles Using Universal Vise
- _____ Grinds Radius
- _____ Squares Up a Block

MEASURING TOOLS

Proficient in the Use of:

- _____ Micrometer
- _____ Vernier, Dial Vernier
- _____ Height Gauge
- _____ Depth Micrometer
- _____ Rockwell Tester
- _____ Telescoping Gauges
- _____ Hole Gauges
- _____ Combination Square
- _____ Dial & Finger Indicator
- _____ Screw Pitch Gauge
- _____ Radius Gauges
- _____ ID & OD Calipers
- _____ Surface Gauge
- _____ Dividers
- _____ Scale or Ruler
- _____ Sine Bar
- _____ Angle Plate
- _____ Performs Precision Layout

DRILL PRESS & RADIAL DRILL

- _____ Understands Parts & Functions
- _____ Sets Up for Drilling
- _____ Sets Up for Reaming
- _____ Sets Up for Tapping
- _____ Drills Various Size Holes to Specs

DRAFTING

- _____ Sketches Parts
- _____ Performs Machine Drawings
- _____ Reads Machine Blueprints

PEDESTAL GRINDER

- _____ Uses Grinder Safety
- _____ Sharpens Drills
- _____ Grinds Various High Speed Tool Bits
- _____ Dresses Wheel & Sets Up Grinder

HEAT TREATING

- _____ Understands Basic Metallurgy
- _____ Performs Basic Heat Treating
- _____ Understands Properties of Steels
- _____ Operates Heat Treating Furnace
- _____ Hardens & Tempers Steel
- _____ Anneals Steel

CUTOFF SAW

- _____ Uses Cutoff Safety
- _____ Selects Saw Blades
- _____ Selects Proper Cutting Speeds
- _____ Operates Saw Properly
- _____ Cuts Round & Flat Stock to Specs

BANDSAW

- _____ Uses Bandsaw Safety
- _____ Welds Blades
- _____ Selects Proper Speed & Feed
- _____ Selects Proper Blades
- _____ Operates Bandsaw Properly
- _____ Cuts Stock to Specs

OTHER

- _____ _____
- _____ _____
- _____ _____
- _____ _____
- _____ _____

WELDING

OXY-ACETYLENE WELDING

- _____ Uses Proper Oxy-Acet Safety Precautions
- _____ Sets Up Equipment Properly and Adjusts Flame
- _____ Weld Grooves & Outside Corner Without Filler Rod
- _____ Welds Groove & Fillet Welds with Filler Rod
- _____ Flat _____ Horizontal
- _____ Vertical _____ Overhead
- _____ Braze-Weld Groove & Fillets
- _____ Braze-Weld Cast Iron
- _____ Braze-Weld Stainless Steel
- _____ Welds Pipe

SHIELDED METAL ARC WELDING

- _____ Uses Proper Safety Precautions
- _____ Understands Power Sources & Equipment, Sets Up, Adjusts Machine
- _____ Properly Positions Welds and Joint Design
- _____ Understands Weld Nomenclature
- _____ Uses Welding Rods Proficiently
- _____ E-6010 _____ E-6011
- _____ E-6013 _____ E-7014
- _____ E-7018 _____ E-7024
- _____ Performs Groove & Fillet Welds
- _____ Flat _____ Horizontal
- _____ Vertical _____ Overhead
- _____ Welds Cast Iron
- _____ Welds Stainless Steel
- _____ Cuts & Pierces With Electric Arc
- _____ Sets Up Air Carbon Arc Equipment
- _____ Gouges & Removes Weld Beads

OXY-FUEL FLAMECUTTING

- _____ Sets Up Manual Torch
- _____ Adjusts Flame
- _____ Straight Cuts Different Thicknesses
- _____ Pierces Holes
- _____ Makes Bevel Cuts
- _____ Sets Up Trackburner and Adjusts Flame

OTHER

- _____ _____
- _____ _____
- _____ _____
- _____ _____
- _____ _____

Instructor's Signature _____

APPENDIX VII

Staff Development Activities

LAKE COUNTY VOC PROJECT SITE SUMMARY FY85 Site Budget $10,000.00

Working Balance ($1,506.69)

ACTUAL EXPENSES

Entry Date	AppNr	Participant	Study Topic	Location	Date of Study	Travel Costs	Substitute Teacher	Registration Fees	Total
8/3		Quality Air Travel-				$0.00	$0.00	$0.00	$0.00
	30	Gregory Valentine	CORD	Dallas, TX	8/2-8/5/84	$253.50			$253.50
8/17		Agency f/Inst Tele-						$0.00	$0.00
	30	Greg Valentine	CORD	Dallas, TX	8/2-8/5/84	$0.00	$0.00	$250.00	$250.00
8/21		Lake Co AVC-		Waubonsee CC-		$0.00	$0.00	$0.00	$0.00
	13	Snider & Whitmer	Digital/Micro W/shop	Aurora, IL	7/30-8/3/85			$143.00	$143.00
	13	Raymond Snider	Digital/Micro W/Shop	Aurora, IL	7/29-8/3/84	$308.30			$308.30
	14	Melvin Whitmer	Digital/Micro W/Shop	Aurora, IL	7/29-8/3/84	$311.80			$311.80
8/31	30	Greg Valentine	CORD	Dallas, TX	8/2-8/5/84	$16.50			$16.50
9/14	29	Wm Kolton	CAD Curr Workshop	Shaumburg, IL	7/5-7/26	$490.05			$490.05
9/18	48	Richard Glogovsky	Inter'l Tool Show	Chicago, IL	9/7/84	$22.04			$22.04
		Lake Co AVC-							$0.00
	48	Richard Glogovsky	Inter'l Tool Show	Chicago, IL	9/7/84			$15.00	$15.00
	49	Gregory Valentine	Inter'l Tool Show	Chicago, IL	9/7/84			$15.00	$15.00
9/24	57	Janet Robinson	Word Proc. Workshop	Rolling Meadows	9/13/84	$7.70			$7.70
	56	Susan Kuss	Word Proc. Workshop	Rolling Meadows	9/13/84	$9.60			$9.60
		Lake Co AVC-							$0.00
	54	Robert Parker	Info. Processing	DeKalb, IL	9/12/84		$40.00		$40.00
	57	Janet Robinson	Word Proc. Workshop	Rolling Meadows	9/13/84		$40.00		$40.00
	55	Janet Robinson	Info. Processing	DeKalb, IL	9/12/84		$40.00		$40.00
10/12	78	Melvin Whitmer	Robotics Seminar	O'Hare Airport	10/9/84	$16.42			$16.42
	73	Janet Robinson	Info Proc Workshop	DeKalb, IL	9/21/84	$24.81			$24.81
		Lake Co AVC-							$0.00
	78	Melvin Whitmer	Robotics Seminar	O'Hare Airport	10/9/84		$30.00		$30.00
	78	PREP, Inc	Robotics Seminar	O'Hare Airport	10/9/84			$50.00	$50.00
		Lake Co AVC-							$0.00
	74	Robert Parker	Info Processing	DeKalb, IL	9/21/84		$40.00	$0.00	$40.00
	73	Janet Robinson	Info Processing	DeKalb, IL	9/21/84		$40.00		$40.00
10/30	72	Karen Curley	Training Seminar	Springfield, IL	10/20/84	$115.96			$115.96
	71	Connie Stamer	Training Seminar	Springfield, IL	10/20/84	$115.96			$115.96
	88	William Kolton	Aidex Training Sem.	Galena, IL	10/14/84	$175.02			$175.02
	69	Marjorie Lambert	Training Seminar	Springfield, IL	10/20/84	$115.96			$115.96
	70	Barbara Rundquist	Training Seminar	Springfield, IL	10/20/84	$213.09			$213.09
		Lake Co AVC-							$0.00
	89	Georgia Von Behren	MESA					$250.00	$250.00
	88	William Kolton	Aidex Training Sem.	Galena, IL	10/15/84	$0.00	$80.00	$0.00	$80.00
	70	Barbara Rundquist	Training Seminar	Springfield, IL	10/22/84		$45.00		$45.00
	69	Marjorie Lambert	Training Seminar	Springfield, IL	10/22/84	$0.00	$45.00	$0.00	$45.00

11/9	86	Michael Francis	Training Seminar	St. Louis	10/30-11/2/84	$174.10	$0.00	$0.00	$174.10	
		Lake Co AVC-				$0.00	$0.00	$0.00	$0.00	
	99	Steve Gurevitz	Emco Maier	Columbus, OH	10/29-10/30/84	$0.00	$60.00	$0.00	$60.00	
	101	Rosemarie Meyer-	Health Curr Mtg	DeKalb, IL	10/29/84	$0.00	$40.00	$0.00	$40.00	
	86	Mike Francis-	Lincoln Tech Inst	St. Louis, MO		$0.00	$120.00	$0.00	$120.00	
		Lake Co AVC				$0.00	$0.00	$0.00	$0.00	
11/13	99	Steve Gurevitz	Emco Maier	Chicago, IL	10/28-10/30/84	$166.24	$0.00	$0.00	$166.24	
	97	Jerry Gudauskas	Tech Ed Symposium	DeKalb, IL	10/4-10/5/84	$70.21	$0.00	$25.00	$95.21	
	99	Steve Gurevitz-	Emco Maier	Chicago, IL	10/28-10/30/84	$326.00	$0.00	$0.00	$326.00	
		Lake Co AVC				$0.00	$0.00	$0.00	$0.00	
	75	Janet Robinson-	List Proc Seminar	Chicago, IL	11/1/84	$0.00	$40.00	$0.00	$40.00	
		Lake Co AVC				$0.00	$0.00	$0.00	$0.00	
	75	Janet Robinson	List Proc Seminar	Chicago, IL	11/1/84	$13.90	$0.00	$0.00	$13.90	
12/4	100	Robert Parker	ETE Word Processing	DeKalb, IL	11/15-11/16/84	$78.68	$0.00	$0.00	$78.68	
	102	Janet Robinson	ETE Word Processing	DeKalb, IL	11/15-11/16/84	$88.18	$0.00	$0.00	$88.18	
	76	Janet Robinson	Wang Labs Train. Sem	Chicago, IL	11/13/84	$14.90	$0.00	$0.00	$14.90	
		Lake Co AVC-				$0.00	$0.00	$0.00	$0.00	
	100	Robert Parker	ETE Word Processing	DeKalb, IL	11/15-11/16/84	$0.00	$80.00	$0.00	$80.00	
	102	Janet Robinson	ETE Word Processing	DeKalb, IL	11/15-11/16/84	$0.00	$80.00	$0.00	$80.00	
	75	Janet Robinson	List Proc Seminar	Chicago, IL	11/13/84	$0.00	$40.00	$0.00	$40.00	
	75	Janet Robinson	List Proc Seminar	Chicago, IL	11/13/84	$0.00	$0.00	$125.00	$125.00	
12/7		Lake Co AVC-				$0.00	$0.00	$0.00	$0.00	
	87	Connie Stamer	Learning Institute	Chicago, IL	11/29/84	$0.00	$45.00	$0.00	$45.00	
	87	Connie Stamer	Learning Institute	Chicago, IL	11/29/84	$19.08	$0.00	$0.00	$19.08	
12/21		Lake Co AVC-				$0.00	$0.00	$0.00	$0.00	
	75	Janet Robinson	List Proc Seminar	Chicago, IL	11/29/84	$0.00	$0.00	$175.00	$175.00	chg. date
	72	Karen Curley	Cosmotology Seminar	Springfield, IL	10/21-10/22/84	$0.00	$0.00	$70.00	$70.00	
	71	Connie Stamer	Cosmotology Seminar	Springfield, IL	10/21-10/22/84	$0.00	$0.00	$70.00	$70.00	
	69	Marjorie Lambert	Cosmotology Seminar	Springfield, IL	10/21-10/22/84	$0.00	$0.00	$70.00	$70.00	
	70	Barbara Rundquist	Cosmetology Seminar	Springfield, IL	10/21-10/22/84	$0.00	$0.00	$70.00	$70.00	
1/21	135	Melvin Whitmer	Electronics Curr	Freeport, IL	1/9-1/11/85	$158.83	$0.00	$0.00	$158.83	
	77	Janet Robinson	Wang Labs Train Sem	Chicago, IL	12/18/85	$14.90	$0.00	$0.00	$14.90	
		Lake Co AVC-				$0.00	$0.00	$0.00	$0.00	
	77	Janet Robinson	Wang Labs Train Sem	Chicago, IL	12/18/85	$0.00	$40.00	$0.00	$40.00	
	135	Melvin Whitmer	Micro Switch	Freeport, IL	1/10-1/11/85	$0.00	$60.00	$0.00	$60.00	
2/6		Lake Co AVC-							$0.00	
	87	Connie Stamer	Learning Institute	Chicago, IL	11/29/84			$67.50	$67.50	
2/11	148	William Kolton	ETE-CAD Workshop	DeKalb, IL	1/31-2/2/85	$66.60			$66.60	
		Lake Co AVC-							$0.00	
	148	William Kolton	ETE-CAD Workshop	DeKalb, IL	1/31-2/2/85		$80.00		$80.00	
2/20	168	Paul Aken	IIEA Spring Conf	Peoria, IL	2/22/85			$11.00	$11.00	
	167	Robert Raukohl	IIEA Spring Conf	Peoria, IL	2/22/85			$11.00	$11.00	
	166	Joseph Pregrocki	IIEA Spring Conf	Peoria, IL	2/22/85			$11.00	$11.00	
	1[illegible]	Gary Merriman	IIEA Spring Conf	Peoria, IL	2[illegible]85			$11.00	$11.[illegible]	
	164	Robert Parker	Info Processing	DeKalb, IL	2/[illegible]/85		$40.00		$40.[illegible]	

	162	Rose Meyer	Health-ETE	DeKalb, IL	2/6/85		$40.00		$40.00	
	163	Jan Robinson	Info Processing	DeKalb, IL	2/5/85		$40.00		$40.00	
	162	Rosemarie Meyer	Health-ETE	DeKalb, IL	2/5-2/6/85	$27.00			$27.00	
	163	Jan Robinson	Info Processing	DeKalb, IL	2/5/85	$29.50			$29.50	
	164	Robert Parker	Info Processing	DeKalb, IL	2/5/85	$29.25			$29.25	
2/26	? 77	Janet Robinson	Multiplan	Chicago IL	12/18/85			$175.00	$175.00	Add Appl # + Loc.
	142	Dick Glogovsky	Prin/Tech Cons Mtg	Louisville, KY	3/7-3/10/85	$98.00		$220.00	$318.00	
3/18		Lake Co AVC-				$0.00	$0.00	$0.00	$0.00	
	147	Melvin Whitmer	Natl Plant Eng/Main	Chicago, IL	3/12/85		$30.00		$30.00	
	149	Robert Parker	Software Instit/Am	Chicago, IL	2/27/85		$40.00		$40.00	
	150	James Sands	Software Instit/Am	Chicago, IL	2/25-2/26/85		$80.00		$80.00	
	165	Gary Merriman	IL Ind Ed Assn	Peoria, IL	2/22/85		$40.00		$40.00	
	168	Paul Aken	IL Ind Ed Assn	Peoria, IL	2/22/85		$30.00		$30.00	
		Lake Co AVC-							$0.00	
	149	Robert Parker	Software Instit/Am	Chicago, IL	~~2/25~~-2/27/85		~~$695.00~~ →	200.00	~~$695.00~~	200.00
	150	James Sands	Software Instit/Am	Chicago, IL	2/25-2/26/85		~~$695.00~~ →	495.00	~~$695.00~~	495.00
3/19	147	Melvin Whitmer	Natl Plan Eng/Main	Chicago, IL	3/12/85	$35.17			$35.17	
	168	Paul Aken	IL Ind Ed Assn	Peoria, IL	2/22-2/23/85	$144.99			$144.99	
	150	James Sands	Software Instit/Am	Chicago, IL	2/25/85 - 2/26/85	$33.60			$33.60	date
	149	Robert Parker	Software Instit/Am	Chicago, IL	2/27/85	$16.80			$16.80	
	165	Gary Merriman	IL Ind Ed Assn	Peoria, IL	2/22-2/23/85	$54.89			$54.89	
	166	Joseph Pregrocki	IL Ind Ed Assn	Peoria, IL	2/22-2/23/85	$54.89			$54.89	
4/1		Lake County AVC-					$0.00		$0.00	
	163	Jan Robinson	Info Processing	DeKalb, IL	3/20/85		$40.00		$40.00	
	164	Robert Parker	Info Processing	DeKalb, IL	3/20/85		$40.00		$40.00	
	163	Jan Robinson	Info Processing	DeKalb, IL	3/20/85	$29.50			$29.50	
	164	Robert Parker	Info Processing	DeKalb, IL	3/20/85	$29.50			$29.50	
4/25	221	Rosemarie Meyer	ETE Health Workshop	DeKalb, IL	4/17-4/18/85	$74.79			$74.79	
	222	Melvin Whitmer	Electronics-ETE	DeKalb, IL	4/17/85	$44.50			$44.50	
4/29		Lake County AVC-				$0.00	$0.00		$0.00	
	221	Rosemarie Meyer	ETE Health Workshop	DeKalb, IL	4/17/85		$40.00		$40.00	
	222	Melvin Whitmer	Electronics-ETE	DeKalb, IL	4/17/85	$0.00	$30.00	$0.00	$30.00	
5/1	196	Barbara Rundquist	Cosmetology Seminar	Springfield, IL	4/20-4/22/85	$198.58			$198.58	
	230	Jan Robinson	Info Processing	DeKalb, IL	4/24/85	$29.50			$29.50	
	229	Robert Parker	Info Processing	DeKalb, IL	4/24/85	$29.50			$29.50	
	195	Marjorie Lambert	Cosmetology Seminar	Springfield, IL	4/20-4/22/85	$96.70			$96.70	
		Lake County AVC-							$0.00	
	196	Barbara Rundquist	Cosmetology Seminar	Springfield, IL	4/20-4/22/85		$45.00		$45.00	
	229	Robert Parker	Info Processing	DeKalb, IL	4/24/85		$40.00		$40.00	
5/8		Lake Co AVC-					$0.00		$0.00	
	233	James Sands	Vo-Tech Data	Springfield, IL	4/29-4/30/85		$80.00		$80.00	
	235	William Kolton	CAD	DeKalb, IL	4/25/85		$40.00		$40.00	
	233	James Sands	Comp-Based Software	Springfield, IL	4/29-4/30/85	$151.77	$0.00		$151.77	
5/20	236	Rosemarie Meyer	ETE-Health	DeKalb, IL	5/1 - 5/2/85	$113.93	$0.00		$113.93	
		Lake Co AVC-					$0.00		$0.00	

	236	Rosemarie Meyer	ETE-Health	DeKalb, IL	5/1-5/2/85			$80.00		$80.00 ✓
		Lake Co AVG-						$0.00		$0.00 ✓
	247	Jan Robinson	Info Processing	DeKalb, IL	5/16/85			$40.00		$40.00 ✓
	249	Melvin Whitmer	Electronics-ETE	Chicago, IL				$30.00		$30.00 ✓
	250	Richard Glogovsky	Mid-Amer Conf	Brookfield, WI	6/10-6/11/85			$0.00	$100.00	$100.00 ✓
5/29	249	Melvin Whitmer	Electronics-ETE	Chicago, IL	5/17/85		$22.50	$0.00		$22.50 ✓
	248	Robert Parker	Info Processing	DeKalb, IL	5/16/85		$29.50	$0.00		$29.50 ✓
	247	Jan Robinson	Info Processing	DeKalb, IL	5/16/85		$29.50	$0.00		$29.50 ✓
								$0.00		$0.00
								$0.00		$0.00
								$0.00		$0.00
								$0.00		$0.00
								$0.00		$0.00
								$0.00		$0.00
								$0.00		$0.00
									FY85 Site Expenditures	$10,046.69
opred m last intout	230	Jan Robinson	Info Proc	DeKalb	4/24/85	—		40.00	—	40.00
	147	Mel Whitmer	Plant Eng	Chicago	3/12/85	—		—	275.00	275.00
	98	Mel Whitmer	Elec	DeKalb	11/15-17/85	84.68		60.00	—	144.68
										9811.37

LAKE COUNTY ESR PROJECT SITE SUMMARY

ENCUMBERED EXPENSES

Entry Date	AppNr	Participant	Study Topic	Location	Date of Study	Travel Costs	Substitute Teacher	Registration Fees	Total	
2/7	142	Richard Glogovsky	CORE/POT	Louisville, KY	3/7-3/10/85	$287.00	$0.00	$0.00	$287.00	Remove - pd
2/11	147	Melvin Whitmer	Plant Eng/Main Conf	Chicago, IL	3/12/85	$0.00	$0.00	$275.00	$275.00	chg to actual
10/8	77	Janet Robinson	Multiplan Seminar	Chicago, IL	12/18/24	$0.00	$0.00	$175.00	$175.00	Remove - pd
11/7	98	Melvin Whitmer	ETE Elect Workshop	DeKalb, IL	11/15-11/17/84	84 ~~$140.00~~	$60.00	$0.00	144 ~~$200.00~~	Chg to actual
2/18	166	Joseph Pregrocki	Ind Ed Assoc Conf	Peoria, IL	2/22-2/23/85	$0.00	$40.00	$0.00	$40.00	Remove
	167	Robert Raukohl	Ind Ed Assoc Conf	Peoria, IL	2/22-2/23/85	$66.00	$40.00	$0.00	$106.00	Remove
3/26	195	Marjorie Lambert	Cosmetology Seminar	Springfield, IL	4/21-4/22/85	$0.00	~~$45.00~~	$70.00	~~$115.00~~ 70.00	Due
	196	Barbara Rundquist	Cosmetology Seminar	Springfield, IL	4/21-4/22/85	$0.00	$0.00	$70.00	$70.00 ✓	Due
5/6	233	James Sands	Vo-Tech Data Systems	Springfield, IL	4/29/85	$0.00	$0.00	$0.00	$0.00 ✓	Remove
	234	Dawn Brumm	School Food Consort.	Grayslake, IL	4/16-4/25/85			$35.00	$35.00 ✓	Due
same II	236	William Kolton	CAD-ETE Workshop	Rockford, IL	4/25/85		$40.00	$0.00	$40.00	Remove - pd
5/9	236	Rosemarie Meyer	ETE-Health Workshop	DeKalb, IL	5/1-5/2/85	$117.00	$0.00		$117.00	Remove - pd
									$0.00	
									$0.00	
									$0.00	
									$0.00	
									$0.00	
									$0.00	
									$0.00	
									$0.00	175.00
								FY85 Encumbered Expenses		~~$1,460.00~~

Working Balance ($1,506.69)

Budget 10,000.00

Pd - 9811.37

Encumbered - 175.00

9986.37 — 9,986.37

Balance 13.63

APPENDIX VIII

Equipment Purchased

ILLINOIS STATE BOARD OF EDUCATION
Department of Adult, Vocational and Technical Education
Compliance Reports
100 North First Street
Springfield, Illinois 62777

— ISBE USE ONLY —	
LEA I.D. CODE	
FY CODE	OCCUPATION AREA CODE
PROGRAM CODE	

REQUEST FOR REIMBURSEMENT
APPROVAL OF INSTRUCTIONAL EQUIPMENT

INSTRUCTIONS: Submit this request with The Local One and Five Year Plan for Occupational Education. Complete a separate sheet for each program.

LEA MUST COMPLETE (Check only one):

☐ Agriculture ☐ Business ☒ Ind. Oriented ☐ General ☐ Home Economics
☐ Health ☐ Personal and Public Services ☐ Audio-Visual ☐ Emerging Occupation

PROGRAM TITLE
COMPUTER ASSISTED DRAFTING

ITEM NO.	QUANTITY	ITEM DESCRIPTION (one item per line)	UNIT COST	TOTAL COST
1.	10	Apple IIe microcomputer system w/dual disk drive, monitor & 80 col. card	1,200.00	12,000.00
2.	20	Super serial card	97.30	1,946.00
3.	1	DMP 42 plotter	2,279.00	2,279.00
4.	1	DMP 40 plotter with cables	1,857.00	1,857.00
5.	1	DMP 29 plotter	1,759.00	1,759.00
				19,841.00

APPENDIX IX

Non-Paid Project Participants

LAKE COUNTY AREA VOCATIONAL CENTER
BOARD OF CONTROL
1985-86

SCHOOL DISTRICT	NAME & TITLE	PHONE	ADDRESS
12	Dr. Duane Andreas, Superintendent Johnsburg Community Unit School	815/ 385-6916	2117 W. Church Street McHenry, Illinois 60050
60	Dr. Donald Torreson, Superintendent Waukegan Community Unit School	336-3100	1201 N. Sheridan Road Waukegan, Illinois 60085
95	Mr. Philip H. McDevitt, Superintendent Lake Zurich Community Unit School	438-2831	66 Church Street Lake Zurich, Illinois 60047
113	Dr. James H. Warren, Superintendent Highland Park - Deerfield High Schools	432-6510	1040 W. Park Ave. West Highland Park, Illinois 60035
115	Dr. Robert H. Metcalf, Superintendent Lake Forest Community High School	234-3600	1285 N. McKinley Lake Forest, Illinois 60045
116	Mr. Clifton A. Houghton, Superintendent Round Lake Community Unit School	546-5522	316 S. Rosedale Court Round Lake, Illinois 60073
117	Mr. Warren Polley, Superintendent Antioch Community High School	395-1421	1133 S. Main Street Antioch, Illinois 60002
118	Dr. Darrell Dick, Superintendent Wauconda Community Unit School	526-6611	555 N. Main Street Wauconda, Illinois 60084
120	Mr. Wayne Bottoni, Superintendent Mundelein Consolidated High School	949-2242	1350 W. Hawley Street Mundelein, Illinois 60060
121	Dr. Paul A. Rundio, Superintendent Warren Township High School	662-4363	500 N. O'Plaine Road Gurnee, Illinois 60031
123	Mr. William Snodgrass, Superintendent North Chicago Community High School	578-7400	1717 - 17th Street North Chicago, Illinois 60064
124	Mr. Lee D. Miller, Superintendent Grant Community High School	587-2561	285 E. Grand Avenue Fox Lake, Illinois 60020
125	Dr. Milton R. Herzog, Superintendent Adlai E. Stevenson High School	634-4000	Illinois Route 22 Prairie View, Illinois 60069
126	Dr. David H. Cox, Superintendent Zion-Benton Township High School	746-1202	1606 W. 23rd Street Zion, Illinois 60099
127	Dr. Griff Powell, Superintendent Grayslake Community High School	223-8621	400 N. Lake Street Grayslake, Illinois 60030
128	Dr. Donald Gossett, Superintendent Libertyville Community High School	367-3159	708 W. Park Avenue Libertyville, Illinois 60048
157	Mr. Ron Erdmann, Superintendent/Prin. Richmond-Burton High School	815/ 678-7211	10006 Main Street Richmond, Illinois 60071
---	Mr. William L. Thompson, Regional Superintendent of Schools, Lake County	689-6313	Room A904 County Building Waukegan, Illinois 60085

LAKE COUNTY AREA VOCATIONAL CENTER

High Tech Consortium

Susan Croy
Abbott Laboratories
Abbott Park
North Chicago IL 60064
937-5404 or 937-6100

Jerry Digilio, Coordinator
Ind. Skill. Craft Trng. Prog.
College of Lake County
19351 W. Washington St.
Grayslake IL 60030
223-6601

Joe Fielding, Instructor
Wauconda High School
555 North Main St.
Wauconda IL 60084
526-6611

Ron Getz
Bran & Lubbe Inc.
512 Northgate Parkway
Wheeling IL 60090
520-0700

Jerry Gudauskas, Exec. Dir.
Lake County Career Guid. Consort.
Lake County Area Vocational Ctr.
19525 W. Washington St.
Grayslake IL 60030
223-6681

Steve Gurevitz, Instructor
Machine Shop
Lake County Area Vocational Center
19525 W. Washington St.
Grayslake IL 60030
223-6681

Daumants Hazners, CAD Instructor
College of Lake County
19351 W. Washington St.
Grayslake IL 60030
223-6601 x 330

Ralph E. Lambrecht
Corporate Director of Service
Outboard Marine Corp.
3145 Central Avenue
Waukegan IL 60085
689-6200

Mike McEvoy, Manager, Design Drafting,
Micrographics & CAD/CAM
Travenol Laboratories
P.O. Box 490
Round Lake IL 60073
546-6311

Rose Meyer, Instructor
Medical Assisting
Lake County Area Vocational Center
19525 W. Washington St.
Grayslake IL 60030
223-6681

Dr. Hans Noll
Professor of Molecular Biology
2665 Orrington Avenue
Evanston IL 60201
492-7329 (b) 866-9796 (h)

John O'Gorden
Curriculum Developer, Naval Education
Building 90
Great Lakes IL 60088
688-~~4697~~ 2484

Carl Painter, Chairman
Eng. Math & Physical Science
College of Lake County
19351 W. Washington St.
Grayslake IL 60030
223-6601

Jule Scarborough, Project Director
Office for Voc Tech & Career Educ.
Northern Illinois University
~~155 Gabel Hall~~ 205 STILL Gym
DeKalb IL 60115
815/753-~~0516~~ 0210, 1349 (message)

Raymond Snider, Instructor
Electronic Equipment Repair
Lake County Area Vocational Center
19525 W. Washington St.
Grayslake IL 60030
223-6601

Melvin Whitmer, Instructor
Industrial Electrical Maintenance
Lake County Area Vocational Center
19525 W. Washington St.
Grayslake IL 60030
223-6681

John Wilson, Mgr, Compensation Benefits
Cherry Electric
3600 Sunset Avenue
Waukegan IL 60085
662-9200

ex-officio:
Nona Denton & Dave Love
ISBE/DAVTE - Research & Development
100 North 1st Street
Springfield IL 62777
217/782-4620

LAKE COUNTY AREA VOCATIONAL CENTER

COMPUTER ASSISTED DRAFTING PROGRAM

ADVISORY COMMITTEE

1984 - 85

Bob Hampton, Chairperson
PRODUCT ENG. - MFG.
AMMCO TOOLS INC.
Wacker Park
North Chicago, IL 60064
689-1111 X 647

Daum Hazner
CAD/CAM INSTRUCTOR
COLLEGE OF LAKE COUNTY
19351 W. Washington St.
Grayslake, IL 60030
223-6601

Jim Resser
CAD/CAM SYSTEM ADMINISTRATOR
COLLEGE OF LAKE COUNTY
19351 W. Washington St.
Grayslake, IL 60030
223-6601

Robert Young
CAE SYSTEM SUPERVISOR
OMC CORP. - MARINE INGINEERING
300 Sea Horse Drive
Waukegan, IL 60085
689-5327

Mike Mc Evoy, Manager
DESIGN DRAFTING, MICROGRAPHICS & CAD/CAM
TRAVENOL LABORATORIES
P.O. BOX 490
Round Lake, IL 60073
546-6311 X564

Ken Wentworth
CAD SECTION MANAGER
Dept. 543
ABBOTT LABORATORIES
North Chicago, IL 60064
937-7274

William Childers
DESIGN SUPERVISOR
ABBOTT LABORATORIES
40620 N. Cornell
Zion, IL 60099
872-8776

Michael Gilfillan, Architect
LEGAT ARCHITECTS
24 N. Chapel
Waukegan, IL 60085
662-3535

ADVISORY COMMITTEE

ELECTRONIC EQUIPMENT REPAIR

1984-85

Mr. Ivan Eddy
CHERRY ELECTRICAL PROD. CORP.
3600 Sunset
Waukegan, IL 60087
662-9200

Mr. Tony Gundrum
COLLEGE OF LAKE COUNTY
19351 W. Washington
Grayslake, IL 60030
223-6601

Mr. Stanley J. Leckie
811 Flossmoor
Waukegan, IL 60085
662-0322

Mr. William Peloza
MICHAEL WILLS TV
1212 Grand Ave.
Waukegan, IL 60085
662-1812

Mr. Melvin Whitmer
LAKE COUNTY AREA VOCATIONAL CENTER
19525 W. Washington St.
Grayslake, IL 60030
223-6681 Ext. 255

Mr. Douglas Smith, Chairperson
SUPERVISOR, DEPT. 736
BUILDING M4
ABBOTT LABORATORIES
North Chicago, IL 60064
937-4929

Mr. Jim Seawright
17617 Summit Dr.
Wildwood, IL 60030
367-0860

Rev. 3/85

ADVISORY COMMITTEE

HEALTH CARE ASSISTANT

1984 - 1985

Ms. Sue Lambert
Respiratory Therapy Dept.
VICTORY MEMORIAL HOSPITAL
1324 Sheridan Road
Waukegan, IL 60085
688 - 3000

Mrs Charlene Hendrickson
LAKE COUNTY HEALTH DEPARTMENT
2400 Belvidere Road
Waukegan, IL 60085
689 - 6700

Mrs Sandra Keske
UPJOHN
800 S. Milwaukee
Libertyville, IL 60048

Mrs Betty Garrett
Executive Director
AMERICAN CANCER SOCIETY
2835 Belvidere Road
Waukegan, IL 60085
336 - 9293

Barb Cochran
WAUKEGAN DEVELOPMENTAL CENTER
Dugdale Circle
Waukegan, IL 60085
249 - 0600 Ext 230

Mr. Lewis Marello
Vocational Coordinator
WAUKEGAN EAST HIGH SCHOOL
1011 Washington St.
Waukegan, IL 60085
336 - 3100

Marty Derlith
MEDICAL ARTS BUILDING
133 N. Greenleaf Ave., Suite 120
Waukegan, IL 60085
249 - 5787

Mrs. Linda Hale, R.N.
DOWNEY VETERANS HOSPITAL
Downey, IL 60064
689 - 1900

Dr. Virginia Thompson
COLLEGE OF LAKE COUNTY
19351 W. Washington
Grayslake, IL 60030
223 - 6601

Mrs. Karen Palmer
ST. THERESE HOSPITAL
2615 W. Washington St.
Waukegan, IL 60085
688 - 2703

Mrs. Margaret Harris
1620 Sunset Ave.
Waukegan, IL 60085
336 - 0058

Mr. Wendal Studebaker, Administrator
CROWN MANOR NURSING HOME
1805 - 27th Street
Zion, IL 60099
746 - 3736

Pat Timmons
Home Nursing
VICTORY MEMORIAL HOSPITAL
1324 Sheridan Road
Waukegan, IL 60085
688 - 3000

Revised 1/18/85

ADVISORY COMMITTEE

INDUSTRIAL ELECTRICAL MAINTENANCE

Lynn Hoselton
ABBOTT LABORATORIES
14th & Sheridan
North Chicago, IL 60064
937-6100/937-6831

Jim Crichton
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Lake Villa, IL 60046
689-6330/356-7050

Ray Snider
LAKE COUNTY AREA VOCATIONAL CENTER
19525 W. Washington St.
Grayslake, IL 60030
223-6681 Ext. 232

Robert Heise
KRUG NORTHWEST ELECTRIC MOTORS
123 Hawley
Grayslake, IL 60030
223-2410

Don Maksimovic
DRAKE ELECTRIC SUPPLY
4210 Grove
Gurnee, IL 60031
623-2028

G. Edward Hucker
HUCKER ELECTRIC COMPANY
1620 Yorkhouse Road
Waukegan, IL 60087
662-8384

Erwin Christensen
CHRISTENSEN ELECTRIC
1501 - 20th Street
Zion, IL 60099
746-2011

Ms. Marjorie Homer
KELSO BURNETT COMPANY
3065 Sheridan Road
Zion, IL 60099
746-2300/458-9765

Clarence Burns
DYNAPAR
1675 Delaney Road
662-2666

Revised 3/85

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1985-86

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577-2650

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949-8787

Rev. 12/6/85

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MEDICAL ASSISTING

1984 - 1985

Dr. Louis Lax, PhD Chairperson Ambulatory Monitoring Lab Inc. 1030 Higgins Road Schaumburg, IL 60195	Work # 843-3921 Home # 662-5529	
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Mr. Gary Daniels St. Therese Hospital 2615 Washington Street Waukegan, IL 60085	Work # 578-2715 Home # 623-3135	
Mr. ~~Pat McNulty~~ ~~100 N. Shaddle~~ Mundelein, IL 60060	Work # 688-6862 668-3701	- Navy Drug Screening Great Lakes Base
Ms. Bonnie Pearson, CMA 2045 E. Grand Avenue Lindenhurst, IL 60046	Work # 356-1080 Home #	
Dr. John Schroeder 1616 Grand Avenue Waukegan, IL 60085	Work # 662-1250 Home #	
*Mr. John Sturcyz 9841 West Paxton Drive Zion, IL 60099	Work # 872-8722 Ext. 243 Home # 872-7909	
*Ms. Remedios Tesch College of Lake County Medical Lab Tech. Dept. 19351 W. Washington Street Grayslake, IL 60030	Work # 223-6601 Home #	

revised 12/13/84
jw

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Troy Kick
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336-1546

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595-1060
Home: 566-4184

ARTICULATION DIRECTORY

1984 - 1985

The Lake County Area Vocational Center has formulated this Articulation Directory to identify key people in the various feeder high schools who are engaged in similar subjects or areas of teaching. Exchange of ideas and curriculum coordination are unlikely to occur unless some medium for communication is developed. It is hoped that this directory will spark communications on the subject of improved articulation between the schools listed below.

PROGRAM AREAS	Lake County Area Vocational Center	College of Lake County	Alden-Hebron High School	Antioch High School	Deerfield High School	Grant High School	Grayslake High School	Highland Park High School	Johnsburg High School	Lake Forest High School	Lake Zurich High School	Libertyville High School	Mundelein High School	North Chicago High School	Richmond-Burton High School	Round Lake High School	Adlai E. Stevenson High School	Warren Township High School	Waukegan High School	Waukegan East High School	Waukegan West High School	Zion Benton High School
	223 6681	223 6601	815/648 2442	395-1421	945-5440	587-2561	223 8621	432-6510	815/385-9233	234-3600	438-5155	367-3100	949-2200	578-7400	815/678-4525	546-2128	634-4000	662-4363	526-6611	336 3100	336-3100	746-1292
Vocational Coordinator/ HEAVC Contact Person	Mike Anderson Ext. 201	Steve Springer Ext. 417	Marsa Woznlak	Adrian Mueller Ext. 270	Jim Chamberlain Ext. 232	Robert Kohler	Paul Subject	Ross Koepnick Ext. 262	S. Pollock or Jim Van Bosch	Dick Triptow	John Hutten	Gary Hodgson Eugene Brakel	Jane Falls Ext. 2208	Georgia Van Cleave 578-7411	Linda Davidson	Ila Bauer/ Ardis Harnagel	Richard Vogtsberger Ext. 216	Dorothy Michno Ext. 87	Fred Loffredo	Arnold Berendsen	Walter Bucks Ext. 612	Dr Jerome Budzik Ext. 214
Air Cond Htg Refrig	Dick Glogovsky Ext. 205	Peter Wintersdorf Ext. 511		Roland Schleusener Ext. 286						Dennis Herrmann Ext. 37		Julian Emanuelson 367-3144										
Auto Body	Jeff Brierton Ext. 219	Jeff Brierton		John Cortez Ext. 286				Alan Kooperman Ext. 262		Bruce Cankar		Julian Emanuelson 367-3144	John Lentz Ext. 2221	Ted Hudson Ext. 27			Robert Hoffman Ext. 206		Dave Falk			John Davis
Auto Mechanics	Pat Yantk Ext 223	Terry Rawlings Ext. 508		John Cortez Ext. 286	J. Chamberlain Ext. 232	Jerry Robinson		Alan Kooperman Ext. 262	Chuck Schultz	Bruce Cankar		Charles Kranz 367-3144	John Lentz Ext. 2221	Ted Hudson Ext. 27		Bruce Britton	Robert Hoffman Ext. 206		Dave Falk	Myron Eyestone Ext. 560	Bruce Yates Ext. 660	Clark Davis Ext. 362
Building Trades	Joe Pregrocka Ext. 252	Doug Beitel Ext. 504		Ken Kasubosk Ext. 286	J. Chamberlain Ext. 232	James Highley	Jerry Allen	Ross Koepnick Ext. 262	John Quick	Dennis Herrmann Ext. 37	Fred Gscheidle	Chuck Swanson 367-3144	Bob Sweeney Ext. 2221	Jorge Colon 578-7437	Dennis Bolsen	George Firnbach	Richard Johannsen Ext. 212	Matt Vanlerberghe Ext. 55	Lonn Calanca	Bob Colpetzer Ext. 560	Jerry Michalski Ext. 660	Jim O'Toola Ext. 357
Child Care	Joanne Fielding Ext. 229	Linda Wetherbe Ext. 536		Glenda Stark Ext. 285	Donna Fitzgerald Ext. 231	Pam Renaker	Susan Boardman	Barb Enns Ext. 272	Rita Gugel	Pat Lanza	Sue Moenning	Ellen Whitmore 367-3171	Elaine Zuehlke Ext. 2201	Sylvia Hu 578-7441		Jean Woods	Susan Petschow Ext. 286	D. Gilmore Mary Dietz Ext. 54	Carol Wall	Connie Sheffield Ext. 544	Joanne Warner Ext. 544	Florence Carlson Ext. 366
Computer Assisted Drafting (CAD)	Bill Kolton Ext. 209	James Rosset Ext. 513		Roland Schleusener Ext. 286	C. Morrison Ext 232		Dan Stacey	Ross Koepnick Ext. 262	Bill Dvonch	Bob Pellnka	Fred Gscheidle	Don Totter 367-3111				Jack Woods	Richard Johannsen Ext. 212		Lonn Calanca	Glen Dolmar Ext. 560		Gary Slocum
Cosmetology	Marge Lambert Ext 263			Adrian Mueller Ext 270					S. Pollock or Jim Van Bosch				Jane Falls Ext. 2208	Georgia Van Cleave 578-7411							Louis Marello Ext. 566	Dr. Jerome Budzik Ext 214
Data Processing	Bob Parker Ext. 218	Dan Petroski Ext. 565	Maria Woznlak	Doug Johnson Ext. 280	K. Cooksey Ext. 247	Sam Spasojevich	Mary Smith		Lois Cocking	George Fossall	Jim Hallett		Jeri Phillips Ext. 2206	Robert Johnson 578-7435	Dave Usrey & Linda Davidson	Ila Bauer	Sam Bitchia Ext. 217	E. Keefauver R Bichey Ext. 58	Dan Thornton Lana Metropulos	Jeff Allen Ext. 545	Terry Thompson Ext. 645	Joe Hutten Ext. 365
Diesel Mechanics	Dick Glogovsky Ext. 205			John Cortez Ext. 286		Jerry Robinson			Chuck Schultz			Charles Kranz 367-3144		Ted Hudson 578-7437		Bruce Britton	Robert Hoffman Ext. 206			Myron Eyestone Ext. 560		John Davis Ext. 362
Electronic Equipment Repair (Formerly Radio/TV Repair)	Ray Sulder Ext. 232	Jack Hudson Ext 492		Dan Schlais Ext. 286	Ross Koepnick Ext 232	James Highley		Ross Koepnick Ext. 262		Dennis Herrmann Ext. 37	Jim Lang	Myron Konkle 367-3144	Bob Sweeney Ext. 2221	Ted Hudson 578-7437					Dave Falk	Boudell Kirkwood Ext. 560		
Fluid Power		Glen Keuss Ext 507								Bruce Cankar							Robert Hoffman Ext. 206	Kurt Bristol Ext. 55				
Land Surveying	Dawn Brumm Ext. 240			Linda Zeaman Ext. 285	H Young Ext. 231	Linda Ikifeldt	Susan Boardman	Kris McKavanagh Ext. 270	Vivian Diserio		Sue Moenning	Ellen Whitmore 367-3171	Elaine Zuehlke Ext 2201	Sylvia Hu 578-7441	Jan Ziemann	Karen Pierce	Jean Wolf Ext. 203	Fran Maurath Ext. 54	Carol Wall	Connie Sheffield Ext. 544	Connie Sheffield Ext. 544	Jean Windberg Ext. 366
Graphic Communications	Paul Aken Ext. 231			Roland Schleusener Ext. 286	Ann Slavick Ext 230			Tom Carlon Ext. 283	Jeff Jerdee			Chuck Swanson 367-3144				Randy Hoff	Bill Kirchherr Ext. 212	Richard Flaker Ext. 55		Al Trafford Ext. 564	Christie Albers Ext. 660	Dick Meyer Ext. 360
Health Care Assistant	Margaret Stamczak Ext. 224	Virginia Thompson Ext. 444		Laurie Ireland Ext. 285	H Fahler Ext 236				Elaine Kee	Jill Bruder	John Zarr	Andy Bitta	Kathie Carr Ext. 2214	Georgia Van Cleave 578 7411		Julie Barnicle	Ken Johnson Ext. 210		Margaret Fosse	Louis Marello Ext. 566	Louis Marello Ext. 566	
Horticulture	Alexis Carlson Ext. 228	Mark Zampardo Ext. 320		Gil Krahn Ext 288					Bob Texidor			Donald Lauer		Georgia Van Cleave 578 7411				Ralph Harvey Ext. 59				
Industrial Electrical Maintenance	Mel Whitmer Ext. 255	Jack Hudson Ext. 492		Dan Schlais Ext. 286		James Highley	Jerry Allen	Ross Koepnick Ext. 262	Bill Dvonch	Dennis Herrmann Ext. 37	Jim Lang	Myron Konkle 367-3144	Jim Jackson Ext. 2221	Ted Hudson 578-7437					Dave Falk	Boudell Kirkwood Ext. 560	Bruce Yates Ext. 660	
Machine Shop	Steve Gorevitz Ext. 250	Jerry Digilio Ext. 492		Stu Good Ext 286	J Chamberlain Ext 232	Dave Kapraun	Jerry Allen					Julian Emanuelson 367-3144	Jim Jackson Ext 2221	Ed Skinner 578-7437	Dennis Borsen	Mr. Ameri			Lonn Calanca	Boudell Kirkwood Ext. 560	Bon Sanderlin Ext. 660	Mike McGue Ext. 223
Media Specialist	Marty Hollander Ext. 247			Tom Herzinger Ext. 260	T Adler Ext 226	William Renaker	Mary Smith	Steve Alsberg Ext. 276		Dave Miller Ext. 37		Don Totter 367-3111		Duane Kovacek		Fran Dayton	Pat O'Donnell Ext. 250	Fred Kattner Ext. 36		Jody Stewart Ext. 559		Karen Grooves Ext. 225
Medical Assisting	Rose Meyer Ext. 217	Virginia Thompson Ext 444		Laurie Ireland Ext. 285					Elaine Kee			Anne Boone		Georgia Van Cleave 578-7411		Julie Barnicle				Louis Marello Ext. 566		David Mayhak Ext. 325
Secretarial Office Occupations	Jan Robinson Ext 236	Donald Holland Ext. 514	Maria Woznlak	Doug Johnson Ext. 280	B Freyding Ext 268	Sandra Hull	Suzanne Sears	Mary Jo Lynch Ext. 295	Jan Bosman	Char Ash	Sally Inhem	Kathy Thompson 367 3172	Judy Stangel Ext 2206	Tim Weber	Linda Davidson	Ila Bauer	Donna Smith Ext. 262	John Ariola Ext 63	Lana Metropulos	Jeff Allen Ext. 545	Flo Spero Ext 645	Mary King Ext. 365
Small Engine Recreational Vehicle	Paul Raupuk Ext 248			Greg Collins Ext. 286	T. Chamberlain Ext 232	Jerry Robinson	Dave Sears	Alan Kooperman Ext 262	Peter Dunk	Bruce Cankar		Harry Carlson 367-3111	Tim Jackson Ext 2221	Ted Hudson 578 7437			Robert Hoffman Ext. 206		Dave Falk	Myron Eyestone Ext. 560	Bruce Yates Ext 660	John Davis Ext. 223
Welding Fabrication	Gary Merriman Ext 232	Jerry Kroll Ext. 215		Stu Good Ext. 286	T Chamberlain Ext 232	Dave Kapraun	Jerry Allen		Chuck Schultz	Bruce Cankar		Julian Emanuelson 367 3111	Tim Jackson Ext 2221	Ed Skinner 578 7437	Dennis Borsen	Mr Ameri			Dave Falk	Boudell Kirkwood Ext. 560	Ron Sanderlin Ext 660	Mike McGue Ext 223

APPENDIX X

Publicity

COME TO

LCAVC

AND

COLOR YOUR FUTURE BRIGHT

PROGRAM AREAS

Business Marketing & Management

Home Economics Occupations

Health Occupations

Applied Biological & Agricultural

Industrial Oriented Occupations

LCAVC PROGRAM AREA

BUSINESS MARKETING & MANAGEME

BUSINESS DATA PROCESSING. The Data Processing program prepares students for entry level positions in the profession of business data processing. Through the use of "hands-on" individualized instruction, students prepare for three entry level areas: 1)computer programming -- using IBM OS/COBOL; 2)computer operations -- using Datapoint minicomputers with telecommunications; 3) data entry -- using on-line and key-to-disk equipment. Upon successful completion of the program, students have the opportunity to earn college credit, as well as to participate in an off-campus work experience in a local industry.

HOME ECONOMICS OCCUPATIONS

COMMERCIAL FOOD SERVICE students are given the opportunity to rotate through various food preparation areas and are allowed to specialize after basic proficiencies are gained. Areas of training include food service operation, basic food preparation, science and math concepts related to food preparation, quantity food production, sales and service, equipment and maintenance, health and safety, sanitation, nutrition, management and inventory control. Actual exprience in quantity and fast food preparation through the use of the Center's snack bar and dining room.

SECRETARIAL OFFICE OCCUPATIONS. The fact that more than 8500 new secretaries are needed each year in Illinois means that secretarial employment opportunities are excellent. In addition to acquiring specific secretarial skills, students receive training on **information processing equipment with software programs such as word processing, multiplan, database, and graphics.** Students leaving the Secretarial Office Occupations program at LCAVC can find employment as **word processing specialists, data systems clerks, administrative assistants, legal secretaries, secretaries, medical transcriptionists, medical records secretaries, receptionists, typists and other related areas.** Students are pictured at work on the Wang OIS 60 Information Processing System.

CARE & GUIDANCE OF CHILDREN. The LCAVC Child Development Center provides a laboratory experience where students "learn by doing" by working with young children. Students gain skills and knowledge in areas related to: guiding the behavior of children, observing and recording behavior, understanding child growth and development, learning preschool operations, and carrying out various activities with children in the preschool. Students have the opportunity to participate in an extended campus training experience during their fourth semester. Graduates are qualified to serve as assistants to teachers in nursery schools, day care centers, kindergartens, and various agencies for exceptional children.

HEALTH OCCUPATIONS

MEDICAL ASSISTING students obtain basic patient skills and knowledge in one or more of the following areas of specialization: 1) Medical Assistant: students perform clinical and lab tasks involved in the care of individuals receiving physicians' services; 2)Lab Assistant: training enables students to execute routine lab procedures; 3)Electrocardiograph Technician: students learn to perform heartbeat tracings with the electrocardiograph, Holter Monitor and other high technology equipment; 4) Medical Secretary-Receptionist: medical office procedures are developed through coordinated efforts in the Secretarial Office Occupations program. A variety of clinical sites (extended campus) allow students to apply skills in real work situations.

HEALTH CARE ASSISTANT is a multi-faceted program at LCAVC. During two years of study, students acquire state certification as a nursing assistant and are able to explore numerous other health subjects including child care, respiratory, physical and occupational therapy, EMT, medical lab, home health care, x-ray and others. "Hands-on" learning is emphasized in the lab which simulates a hospital setting. Extended campus or internship learning activities are included in all areas. State regulations now require nursing home and home health care workers to be certified and the employment outlook for certified workers is excellent. This program also provides a strong base for those students who go on to higher education in the health care field.

Discover LCAVC

An Exciting Place To Be

STRUCTURE

Lake County Area Vocational Center is an extension of its member districts' curriculum. The facility presently serves juniors and seniors from cooperating high school districts in Lake and McHenry counties.

CURRICULUM

Program curriculum is designed to meet current job market needs and is revised annually to keep training skills up-to-date.

FACILITY/EQUIPMENT

LCAVC is able to provide labs and real work world settings for a learning environment that students find challenging and enjoyable. Latest training equipment is used to teach new technology concepts practiced in business and industry.

INSTRUCTIONAL SYSTEM

Emphasis is placed on student participation in actual or simulated job and production situations. An individualized approach to training allows students to advance at their own pace and acquire knowledge of skills necessary for employment or advanced training.

OCCUPATIONAL ADVISORY COMMITTEES

These committees review the curriculum, suggest appropriate instructional equipment and give service to program instructors and Center administrators.

You are invited to visit LCAVC, meet the instructors, tour the facilities and observe the programs in operation. For more information, see your high school counselor or call (312) 223-6681

Lake County Area Vocational Center, 19525 West Washington Street, Grayslake, Illinois 60030

High - Tech Grant . . .
Second Year of initiative

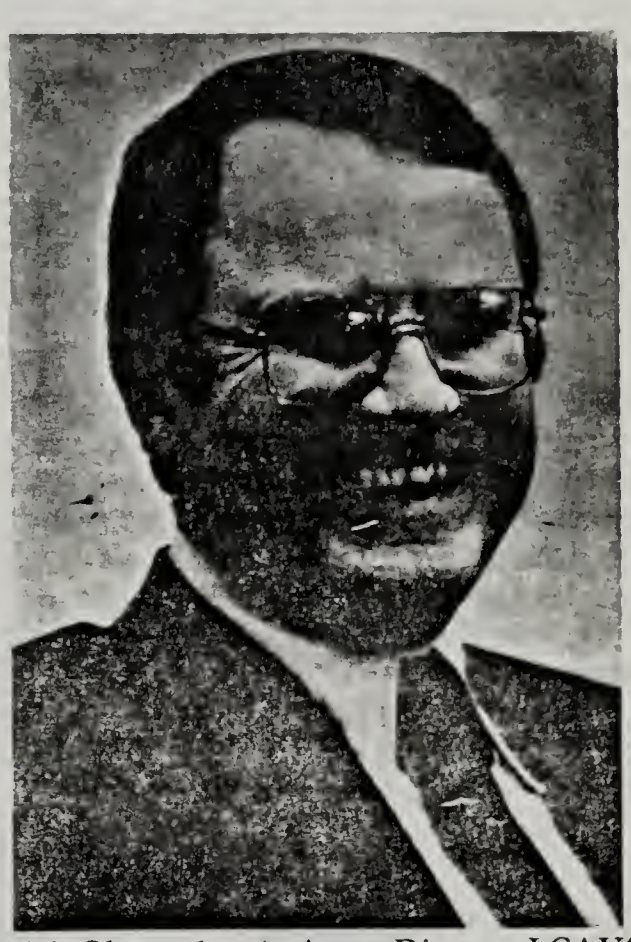
Lake County Area Vocational Center is playing important role in developing course materials ıich will be used to prepare high school students employabilty in the 'High Tech' world of norrow.

Under a one million dollar state legislative apopriation in the education budget approved by ›vernor James Thompson, LCAVC will receive)0,000 to pursue this initiative. The Vocational nter is one of eight Illinios secondary school at will be cooperating with Northern Illinios ıiversity technical assistance faculty in attaining e state long-range initiative - Education for :chnology Employment. This is the center's send year of involvment in the project. The intent this initiative is to formulate, as an integral part the secondary vocational program, those basic :hnical and employability skills that will conbute to the entry-level employment and/or ure education for the high school student.

Last school year (1983-84), grant money was ed to develop and field test new technology cur-u' nd equipment into a variety of LCAVC s. As a result, robotics, pnuematics and microprocessors have been integrated into the Industrial Electrical Maintenance program. A unit on microcomputer repair has been included into the Electronic Equipment Repair program. Computer numerical control metalworking equipment has been placed into the Machine Shop program. Information processing skills are now being taught through the use of the Wang word processor in the Secretarial Office Occupations program.

This year (1984-85), the center will identify, develop and field test new technology curriculum and equipment in the Computer Assisted Drafting and Medical Assisting program areas.

Curriculum materials, including task lists, suggested equipment and methods of staff training will be delivered to the Illinois Department of Adult, Vocational and Technical Education upon completion of the project. These materials will then be shared with all secondary high schools and vocational centers in the state. The Lake County Area Vocational Center is proud to be participating in this most important project.



Dick Glogovsky, Assistant Director LCAVC

LCAVC

LAKE
COUNTY
AREA
VOCATIONAL
CENTER

19525 W.Washington Street
Grayslake, Illinois 60030

C.A.D. (Computer Assisted Drafting) New Technology at LCAVC

puters are affecting our life more and ore, and like everything else, computers are af-cting the drafting industry also. Computer ssisted Drafting (CAD) has placed the conven-onal drafting board, compass, eraser, and lead older. At a CAD station the draftsperson perates a stylus and by digitizing a graphic tablet, eates a drawing that takes 3 to 4 times longer sing conventional means.

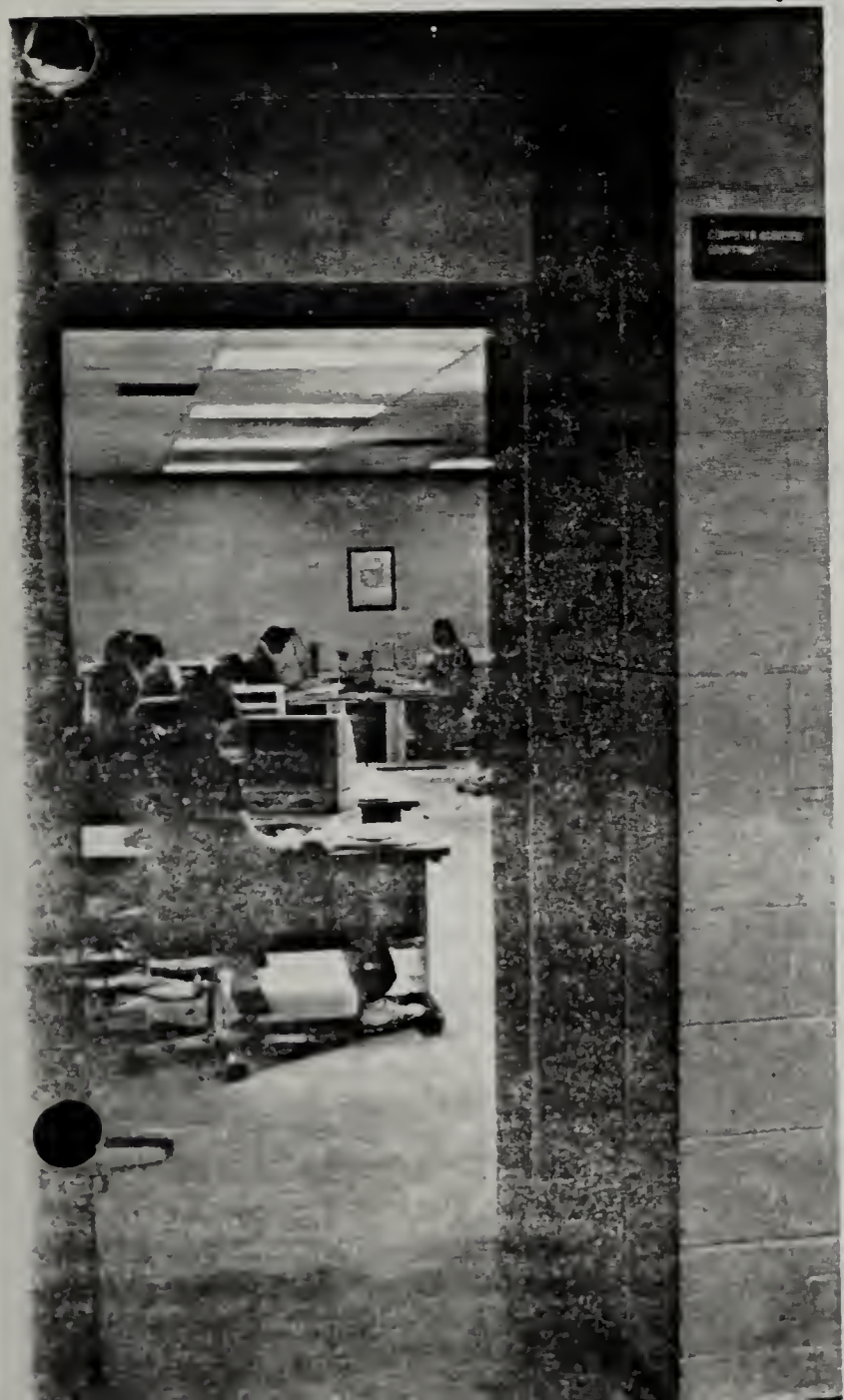
At the Lake County Area Vocational Center, omputer Assisted Drafting is being taught rough competency based instruction. The urse is divided into four areas: (1) Introduction CAD, (2) Two Dimensional CAD, (3) Three imensional CAD, (4) Project Work. A brief escription of each unit follows:

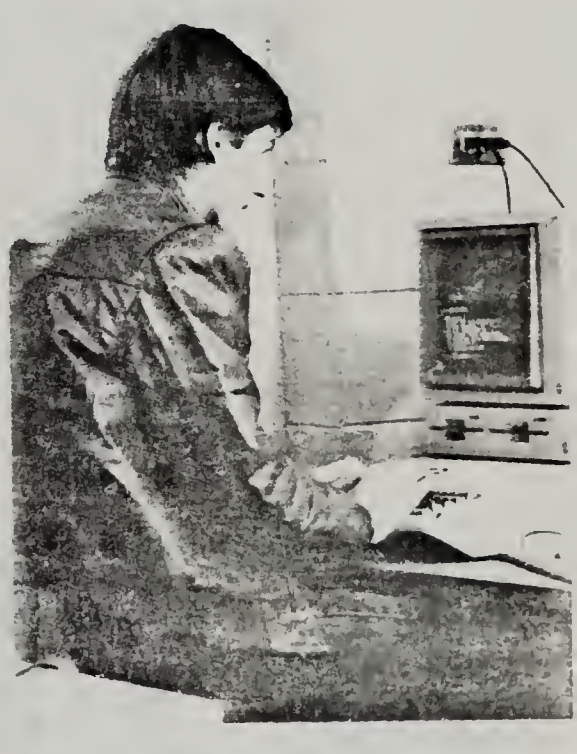
1. Introduction to CAD
   The student is introduced to CAD. The management and value of time as it applies to industry and how CAD can draw faster than convensional drafting is stressed. Also discussed in this unit are the CAD applications and possible careers in CAD (role of CAD personnal in the drafting industry).
2. Two Dimentional CAD
   This unit is much like a basic introductory drafting course. The students learn how to scale a drawing, but instead of using a rule (scale) they learn how to scale a drawing using a CAD system - it is much different. They also learn to establish a coordinate system: Absolute, Relative, and Polar. Students learn how to draw a problem using two different techniques: (1) from a digitizer tablet and, (2) from a keyboard. Also in this unit the students learn manipualation of entities; this is where the speed and accuracy of CAD outshines conventional drafting practices. Finally, dimensioning is covered in this unit. This is also different from past techniques
3. Three Dimension CAD
   In this unit students learn to think in a X, Y, and Z axis and with this create views through projection and rotation.
4. Project Work
   The student is now prepared to work on problems of there own choice. Such problems could be architectural, mechanical, and electrical in nature.

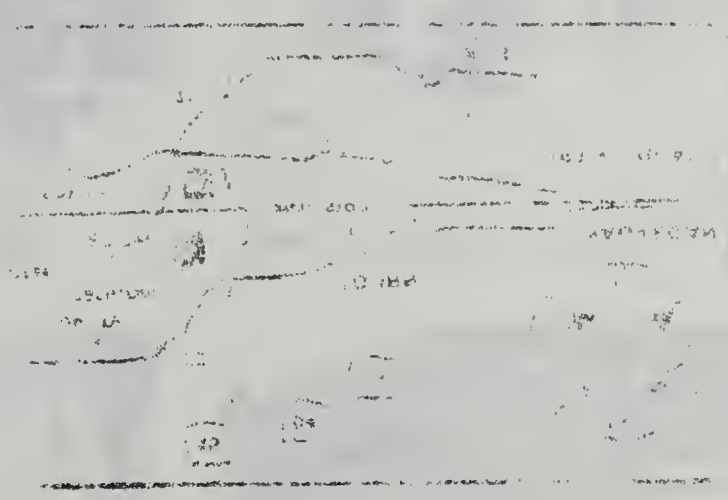
The prerequisite for entry in Computer Assisted Drafting is one to two semesters of drafting at the home school. One semester for those students with advanced math experience, and two semesters for those without. The CAD course at LCAVC is taught by Bill Kolton.

Mr. Kolton was raised in the Milwaukee area. After graduation from high school he was employed at Howard, Needles, Tammen, and Bergendorff, a consulting engineering firm, they developed such projects as the Milwaukee Freeway and Milwaukee Court House Annex. Bill worked there for one year and was drafted into the Army. After completing his obligation which included 18 months in Vietnam, he went to college and graduated with honors with a Bachelor of Science Degree in Industrial Education from the University of Wisconsin-Stout. He then accepted a teaching position at Seymour Community High School, Seymour Wisconsin. There he taught seven years as the principle drafting instructor, teaching courses in mechanical and architectural design. This past summer he received a Master of Science Degree in Vocational Education from UW-Stout.

Bill looks forward to the challenge of working with Lake County students and the Vocational Center.







ATTENTION PARENTS!

We want to show your teenager how to start building a career as part of his/her high school program.

Lake County Area Vocational Center

Open House

Sunday, January 13

1:00 - 4:00 p.m.

Visit classes in over 20 different occupational training programs! See students demonstrate what they are learning and talk to experienced instructors about tomorrow's career opportunities.

FOR MORE INFORMATION, CALL LCAVC 223-6681

Here's what LCAVC graduates say:

LCAVC training prepared me for the actual working class status, which made the transition from high school to full-time employment much easier

I have learned a lot at the center. I got my job right after graduation. "Mr. Aken" has a lot of class. I give him credit for everything he taught me. The Center was "Great"

The teachers in my program were exceptional.

LCAVC is the best opportunity any student could have.

Thank you for the program. It has set me up for lifetime career, I couldn't have done it myself.

Here's what employers say about LCAVC graduates:

"Very good program keep up the good work. Waiting for more people to work with."

"If he didn't have the training, he wouldn't have the job."

"This employee is very good. We value her abilities."

"This person is a very productive and cooperative employee."

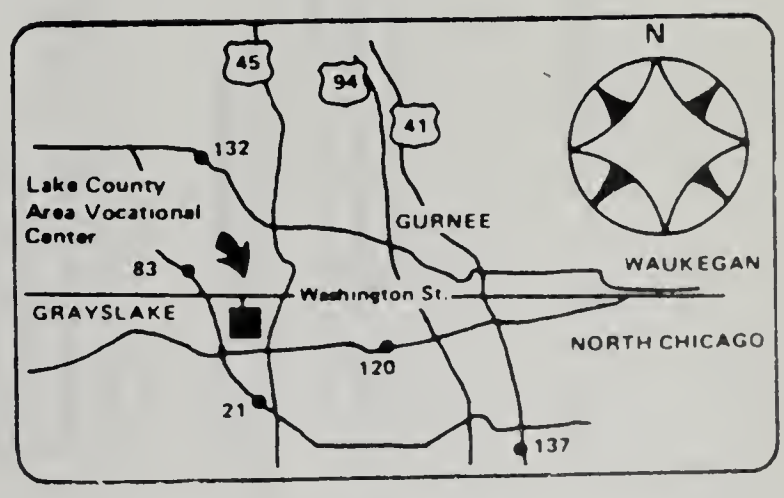
"The individual seems to know the terms. He has good gereral knowledge."

"Good employee would like to have a few others like him."

"Better grasp of assignment than other employees."

"Very well spent tax dollars. The education received is appreciated."

"This employee shows exceptional ability and is an excellent employee."



Lake County Area Vocational Center
19525 W. Washington St.
Grayslake, IL 60030

(just north of the College of Lake County)

FUTURE OCCUPATIONS

U.S. Dept. of Labor Information
Twenty Fastest Growing Occupations
1982-95

Occupation	Percent Growth in Employment	Employment Growth (in 1,000's)
Computer Service Technicians	96.8	53*
Legal Assistants	94.3	43
Computer Systems Analysts	85.3	217*
Computer Programmers	76.9	205*
Computer Operations	75.8	160*
Office Machine Repairers	71.7	43*
Physical Therapy Assistants	67.8	22
Electrical Engineers	65.3	209*
Civil Engineering Technicians	63.9	23*
Peripheral EDP Equipment Operators	63.5	31*
Insurance Clerks, Medical	62.2	53
Electrical & Electronic Technicians	60.7	222*
Occupational Therapists	59.8	15
Surveyor Helpers	58.6	23
Credit Clerks, Banking & Insurance	54.1	26
Physical Therapists	53.6	26
Employment Interviewers	52.5	19
Mechanical Engineers	52.1	109*
Mechanical Engineering Technicians	51.6	24*
Compression & Injection Mold Machine Operators, Plastics	50.3	47
Total Projected Job Openings		1,570,000
Total 'High Tech' Job Openings		1,296,000

Includes only detailed occupations with employment of 25,000 or more. Data for 1995 is based on moderate trend projections. 'High Tech' occupations are marked witha *. Please note that this implies a very liberal definition of 'high tech' occupations.

Why VocEd?

Why vocational education? In an article in VocEd, Journal of the American Vocational Association, the following answer is provided:

- Voc ed increases educational options

- Voc ed enriches a college bound student's background, providing future engineers with drafting and electronics skills, hotel management professionals with food trade skills, businessmen and women with retailing or computer programming skills, and so on.

- Voc ed is a "pre college" program for many high tech post-secondary programs.

- Voc ed helps students decide what they want to do for a living. Child care helps students discover whether they really like working with children; auto repair helps car-crazy would be mechanics find out if they really want to be one; and so on.

- Voc ed teaches language, math, and science skills in the context of career interests.

- Voc ed expands a student's horizons by providing transferable skills and universal workplace attitudes.

- Voc ed gives students the wage earning potential to support themselves in college.

Source: Charles W. Brodhead, "Polishing the Image," VocEd. November/December, 1984.

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Vocational Center trains over 1,000 a year

The Lake County Area Vocational Center trains more than 1,000 high school students for the work force each year.

Instruction, related to eight of the 12 fastest growing occupations over the next 10 years, is available at the Grayslake-based center.

According to the U.S. Department of Labor, those occupations are computer service technician, computer programmer, computer operator, physical therapy assistant and electronic data processing equipment operators, medical insurance technicians, electrical and electronic technicians and restaurant chefs.

Courses at LCVC are designed for juniors and seniors who are bused to and from the center daily from their high schools. Classes are just over two hours long.

The student's high school district pays the tuition.

The labor market, employment trends, student interest and employer feedback led to the design of the LCAVC and its curriculum. Each occupational program is reviewed annually to keep current with state-of-the-art equipment and training, and the needs of the job market.

Classrooms resemble actual work settings. Job projects involve students as they advance at their own pace.

In one of the center's newest programs, computer-assisted drafting, students learn how to operate a computer stylus and "digester tablet" to create a drawing in less time than on a convetional drawing board.

Students in industrial electrical maintenance classes learn how to distribute power by conduit and run cable lines. The program, with its expanded coverage of pneumatics and robotics, offers a strong beginning for students who plan to enter the field of high technology maintenance.

In another industrial-oriented course, electronic equipment repair, students study basic electricity and work with transistors, and integrated and digital circuits. First-year students learn concepts through self-study guides and experimentation. In the second year, students learn how to read schematic diagrams and how to test, diagnose, adjust and repair equipment. Students then specialize in either entertainment equipment repair or microcomputer repair.

The business data processing program prepares students for entry level positions in computer programming, computer operations or data entry.

Commerical food service students gain experience in food preparation, quantity production, sales and service, healthy and safety considerations, management and inventory control. Actual experience in quanitity and fast food prepration in given through the use of the center's snack bar and dining room.